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BULLETIN No. 68.

YIELD AND GROWTH IN HEVEA BRASILIENSIS.

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DEPARTMENT OF AGRICULTURE, CEYLON.

BULLETIN No. 68.

YIELD AND GROWTH IN HEVEA BRASILIENSIS.

INTRODUCTION.

SOME simple method of determining the best yielding trees is generally required by rubber planters. If individual yield records could be kept on estates, the best and worst yielding trees would be known, but the collection of such yield records is not practicable, and such information is, therefore, generally not available. If, however, the yielding capacity of a tree could be accurately gauged by some vegetative character, such as cortex thickness, or girth, which can be measured easily, the detection of the best yielding trees would be facilitated, and their selection thus made easy.

Selection of Hevea trees is made for two purposes, viz. :—

(1) To ascertain the poor yielders in order that they may be removed in thinning; and

(2) To ascertain the highest yielders for the purpose of propagation.

In a previous publication [4] are recorded certain data from a plot at Peradeniya Experiment Station of 161 trees raised from seed of the well-known, high-yielding, Henaratgoda No. 2 tree. These data include measurements of girth, cortex thickness, number of rows of latex vessels in the cortex (made in April, 1921, at the commencement of tapping, when the trees were 10 years old), and the yield for the first 10 months of tapping. Certain relationships were found between yield and girth, cortex thickness, and number of rows of latex vessels. It was considered desirable to repeat the investigation for the second year of tapping to ascertain if any change had occurred in the relationships recorded. At the same time it was decided that the scope of the investigation could usefully be extended to include relationships between other characters.

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With these objects in view, further specimens of cortex were taken, and other data requisite were collected. The specimens of cortex were taken in April, 1923, from the following positions :—

(1) Untapped cortex at 2 feet from ground level, adjacent to the spot from which the 1921 specimen was taken.
(2) Untapped cortex at 16 inches below (1), *i.e.*, at 8 inches above ground level.
(3) Renewing cortex at 2 feet adjacent to (1).

The figure (Fig. 1) illustrates the positions from which the cortex specimens were taken. In many cases large lateral roots have their origin on the stem at a point several inches

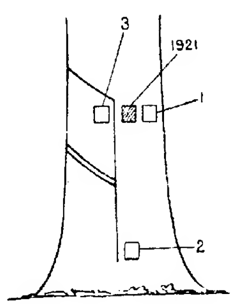

Fig. 1.

above ground level, and for this reason specimens were taken at 8 inches above ground level to ensure that root cortex was not included. From these specimens measurements of cortex thickness and number of latex vessel rows were taken, the methods employed being as described in Bulletin 55.

Girth was measured at 3 feet above ground level, at the same time, to conform with previous girth measurements.

Tapping was continued by the same tapping cooly throughout the year on alternate days, the trees being given no rest period. The same method of coagulation of the latex in the collecting cups was continued.

The yields given in Bulletin 55 [4] were for the first 10 months of tapping only, April 1, 1921, to January 31, 1922; the yields for the first complete year are now given in Table 1.* In this table are also recorded measurements for 1922–23 of the various characters referred to above. All yield figures are given in grammes of dry rubber.

During the course of these investigations six trees (Nos. 11, 22, 76, 85, 88, and 111) have practically ceased to yield latex. Tapping has, however, been continued on these trees. In view of their abnormal condition, data referring to them have not been included in the present investigation, which is therefore based on the remaining 155 trees.

Before proceeding to examine the physiological interrelationships of the various characters, a preliminary study of these characters is desirable to obtain information as to their variability. Such a study has already been made in Bulletin 55, and has been carried on in the present Bulletin in Part I. The investigation then proceeds to the examination of the physiological interrelationships in Part II. The application to estate practice of conclusions reached as a result of the present investigation is discussed in Part III.

PART I.

Yield.

The yields of the 155 trees for the tapping year, 1921–22, ranged from 1,392 grammes (Tree 118) to 3,693 grammes of dry rubber (Tree 67), the mean yield being 2,249 grammes. It was pointed out in Bulletin 55 [4] that the yields are not evenly distributed throughout the range, but cluster round a point just below the mean. When the frequency distribution (Table 2) is expressed in the form of a graph, a curve is obtained which is approximately "normal." For convenience of comparison the curves for the tapping years, 1921–22 and 1922–23, are given on the same ordinates in Fig. 2. The 1922–23 curve is slightly skewed towards the lower limit of the range, the skewness, however, being considerably less than that in curves of yields of mixed populations (*cf.* Bulletin 55, Fig. 3).

* This table is given at the end of the Bulletin.

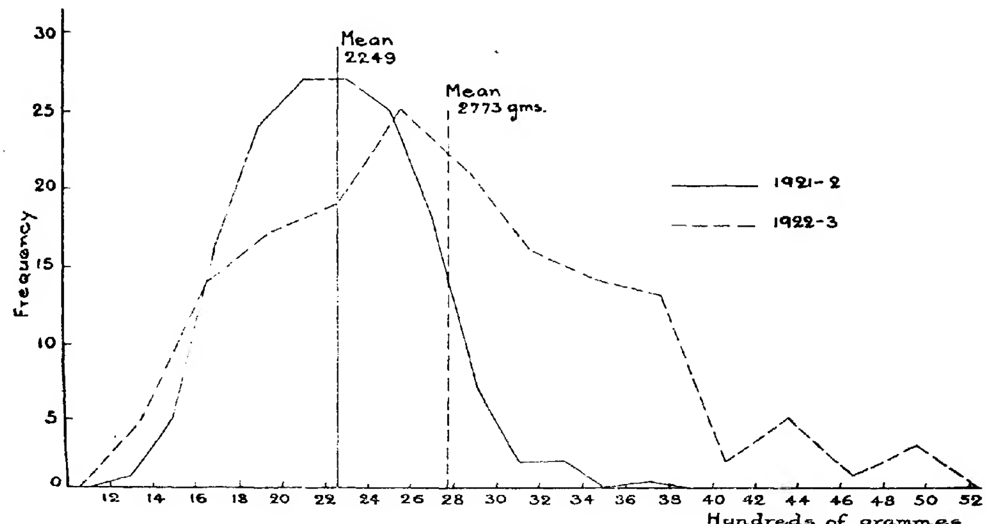

Fig. 2.—Frequency polygons for yield, 1921–22, and 1922–23.

Table 2.

Frequency Distribution of Yield for 1922–23.

Yield. Grammes.	Frequency.	Yield. Grammes.	Frequency.
1,200–1,499 ..	5	3,300–3,599 ..	14
1,500–1,799 ..	14	3,600–3,899 ..	13
1,800–2,099 ..	17	3,900–4,199 ..	2
2,100–2,399 ..	19	4,200–4,499 ..	5
2,400–2,699 ..	25	4,500–4,799 ..	1
2,700–2,999 ..	21	4,800–5,099 ..	3
3,000–3,299 ..	16		

For the tapping year, 1922–23, the yields ranged from 1,330 grammes (Tree 118) to 5,088 grammes (Tree 5), the mean yield being 2,773 grammes. The range, 3,758 grammes, is thus considerably greater than that of the previous year, 2,301 grammes. This indicates a greater variation in yield in the second year. The variability of one year may be readily compared with that of another year by means of the coefficient of variability. The coefficient of variability of the 161 trees for the first 10 months of tapping was given as 19·1 ; for the first 12 months' tapping of the 155 trees it was found to be 18·2 ; and for the second 12 months 29·2. The coefficient for the second year is thus greater than that for the first year, but is still much lower than those given for mixed populations by Whitby [10] and la Rue.[8] (76·19 and 60·32 respectively).

The yield curve for the second year exhibits an increased skewness. The skewness of the curve for the first year has been measured and found to be ·095, whereas for the second year it was ·289. Though the skewness has increased in the second year, it is still not so marked as that for a mixed population, for which Whitby [10] gives a coefficient of skewness of ·575.

Increase in Yield.

The mean yield has risen from 2,249 grammes in 1921–22 to 2,773 grammes in 1922–23, an increase of 23·3 per cent. The increase in yield of each tree has been expressed as a percentage of the first year's yield. It was found that Tree 109 had increased in yield by 70·7 per cent., whereas Tree 100 showed a decrease of 33·6 per cent., between which limits all the other percentage increases or decreases fall.

The frequency distribution of the percentage increase in yield is given in Table 3, and represented graphically in Fig 3.

Table 3.

Frequency Distribution of Percentage Increases in Yield.

Percentage Increase.	Frequency.	Percentage Increase.	Frequency.
— 35 to — 25·1 ..	3	+ 25 to + 34·9 ..	31
— 25 to — 15·1 ..	6	+ 35 to + 44·9 ..	21
— 15 to — 5·1 ..	7	+ 45 to + 54·9 ..	13
— 5 to + 4·9 ..	15	+ 55 to + 64·9 ..	3
+ 5 to + 14·9 ..	24	+ 65 to + 74·9 ..	2
+ 15 to + 24·9 ..	30		

From Fig. 3 it will be seen that the most frequent increase in yield lies between 20 and 30 per cent. The mean percentage increase is 21·29 per cent., and the coefficient of variability has been calculated to be 96. This high coefficient of variability indicates that there is a much greater variability in percentage increase in yield than there is in actual yield.

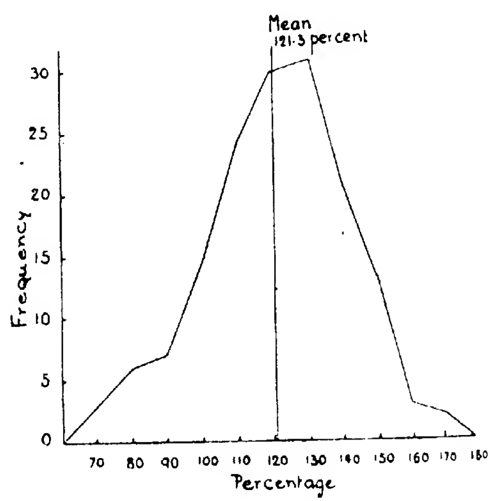

Fig. 3.—Frequency polygon for the percentage increase in yield.

Since increase in yield exhibits great variability, it would appear to be important to determine: (1) whether the trees which gave the highest yields in 1921–22 also gave the highest yields in 1922-23; and (2) whether the highest yielders have given the greatest proportional increases in yield.

Table 4.

Correlation between Yield, 1921–22, and Yield, 1922–23.

Yield, 1922–23, in Grammes.		Yield, 1921–22, in Hundreds of Grammes. 13	15	17	19	21	23	25	27	29	31	33	35	37		Total.
1,250	..	1	.	.	1	.	.	.	.	.	.	.	.	.	..	2
1,500	..	.	2	3	.	.	.	.	.	.	.	.	.	.	..	5
1,750	..	.	2	7	5	1	1	1	.	.	.	.	.	.	..	17
2,000	..	.	1	3	4	1	2	1	2	.	.	.	.	.	..	14
2,250	..	.	.	2	7	6	2	.	.	.	.	.	.	.	..	17
2,500	..	.	.	1	4	9	4	1	.	.	.	.	.	.	..	19
2,750	..	.	.	.	3	5	5	1	.	.	.	.	.	.	..	14
3,000	..	.	.	.	.	5	5	8	3	.	.	.	.	.	..	21
3,250	..	.	.	.	.	.	5	5	1	.	.	.	.	.	..	11
3,500	..	.	.	.	.	.	3	2	5	1	.	.	.	.	..	11
3,750	..	.	.	.	.	.	.	6	3	3	1	.	.	.	..	13
4,000	..	.	.	.	.	.	.	.	1	.	.	.	.	.	..	1
4,250	..	.	.	.	.	.	.	.	1	2	.	1	.	.	..	4
4,500	..	.	.	.	.	.	.	.	1	1	.	.	.	.	..	2
4,750	..	.	.	.	.	.	.	.	1	.	.	.	.	.	..	1
5,000	..	.	.	.	.	.	.	.	.	.	1	1	.	1	..	3
Total	..	1	5	16	24	27	27	25	18	7	2	2	0	1		155

Yield, 1922–23.		Yield, 1921–22.	
Mean.	Standard Deviation.	Mean.	Standard Deviation.
2,773 gm.	810·1 gm.	2,249 gm.	410·2 gm.

Coefficient of correlation $= + \cdot 83 \pm \cdot 017$.

The degree of relationship existing between the yield in 1921–22 with that of 1922–23 is shown in Table 4. From this table the coefficient of correlation has been calculated to be $+ \cdot 83 \pm \cdot 017$. This indicates that a very close relationship exists between the yielding capacity of a tree in one year with its capacity in the succeeding year, and that on the average the high yielders of one year are also high yielders the following year. That the rule is not absolute is shown by the coefficient of correlation being less than unity. Consequently, it is to be expected that a careful examination of the individual yield records will show that some trees, which in the first year might have been termed high yielders, have during the second year of tapping become mediocre or even poor yielders. Such an examination was made, and the fact was revealed that Tree No. 67 which gave the highest yield in 1921–22 had fallen to 3rd place in 1922–23. Tree No. 48 fell from 21st place to 119th, Tree No. 100 from 31st to 143rd, and Tree No. 161 from 13th to 126th, and numerous other changes in the order of merit have occurred. Such changes would be expected owing to the great variability exhibited by increase in yield.

That the highest yielders have on the average made the greatest proportional increase in yield may be seen from Table 5 showing the correlation between yield, 1921–22, and the percentage increase in yield. The coefficient of correlation for these characters has been calculated to be $+ \cdot 39 \pm \cdot 046$ which indicates a marked relationship between these characters.

The trees of the plot may conveniently be divided into three groups: (1) high-yielding, (2) medium, and (3) low-yielding. If approximately half the trees are placed in the medium group, the limits of that class can be defined by means of the probable error of a single result.[6] The trees outside this class and at the upper end of the range will then form the high-yielding group, and conversely those at the lower end of the range will form the low-yielding group. This gives a convenient form of classification which will be frequently used in the following pages in connection with other characters. It will be noted that the class limits are obtained by computation, and that they are thus free from any bias due to personal selection.

In 1921–22 the mean yield was 2,249 grammes of dry rubber, and the probable error of a single result $\pm$ 276 grammes. The medium class will, therefore, include all trees with yields lying

Table 5.

Correlation between Yield, 1921–22, and Percentage Increase in Yield, 1921–23.

Yield, 1921–22, in Grammes.	Percentage Increase in Yield. —30	—20	—10	0	10	20	30	40	50	60	70	Total.
1,300 ..	.	.	.	1	.	.	.	.	.	.	.	1
1,500 ..	.	.	1	1	2	1	.	.	.	.	.	5
1,700 ..	.	2	1	5	2	2	2	1	1	.	.	16
1,900 ..	1	.	3	3	7	5	2	3	.	.	.	24
2,100 ..	.	1	.	3	6	7	3	5	2	.	.	27
2,300 ..	.	1	2	2	3	4	8	2	5	.	.	27
2,500 ..	1	1	.	.	2	8	4	6	3	.	.	25
2,700 ..	1	1	.	.	2	2	6	3	.	2	1	18
2,900 ..	.	.	.	.	.	1	3	1	1	1	.	7
3,100 ..	.	.	.	.	.	.	1	.	.	.	1	2
3,300 ..	.	.	.	.	.	.	1	.	1	.	.	2
3,500 ..	.	.	.	.	.	.	.	.	.	.	.	0
3,700 ..	.	.	.	.	.	.	1	.	.	.	.	1
Total ..	3	6	7	15	24	30	31	21	13	3	2	155

Yield, 1921–22. Mean.	Yield, 1921–22. Standard Deviation.	Percentage Increase in Yield. Mean.	Percentage Increase in Yield. Standard Deviation.
2,249 gm.	410·2 gm.	21·3 per cent.	20·4 per cent.

Coefficient of correlation = + ·39 ± ·046.

between 1,973 grammes and 2,525 grammes, the trees forming the low-yielding group are those with yields of less than 1,973 grammes, and the high-yielding group those having yields greater than 2,525 grammes. From an examination of Table 1 it can be ascertained that there were in 1921–22, 43 trees in the low-yielding group and 39 in the high-yielding group. A comparison of the mean yield records of these two groups is given in Table 6.

Table 6.

Comparison of Low-yielding Group with High-yielding Group.

	Number of Trees in Group.	Mean Yield. 1921–22.	Mean Yield. 1922–23.	Increase of Mean.	Mean Increase as Percentage of 1921–22 Yield.
		Grammes.	Grammes.	Grammes.	Grammes.
Low Group ..	43 ..	1,778 ..	1,945 ..	167 ..	$9 \cdot 3 \pm 1 \cdot 74$
High Group ..	39 ..	2,779 ..	3,647 ..	868 ..	$30 \cdot 8 \pm 2 \cdot 42$

It will be seen from the foregoing table that the mean yield of the High Group in 1922–23 has increased by a greater amount than has the mean of the Low Group. Moreover, the mean increase, in proportion to the 1921–22 yields, is greater in the High than in the Low-yielding Group. The difference between the percentage increase in yield of the High and Low Groups is $21 \cdot 5 \pm 2 \cdot 98$ per cent. This difference is statistically significant, and indicates that the difference is real, and is not due merely to the variation of the percentage increases used in obtaining the averages. It may, therefore, be definitely concluded that, on the average, the trees which had the highest yields in 1921–22 have shown the greatest increases in yield during the following year. The increases are greater, not only in nett amount, but also in proportion to the initial yields.

Girth.

The frequency distribution of girth measurements made in 1923 is given in Table 7, and is given in graph form in Fig. 4. Here, as in the case of yield, the girth curves for 1921 and 1923 are given on the same ordinates. It will be noticed that the distribution for 1923 resembles closely that for 1921.

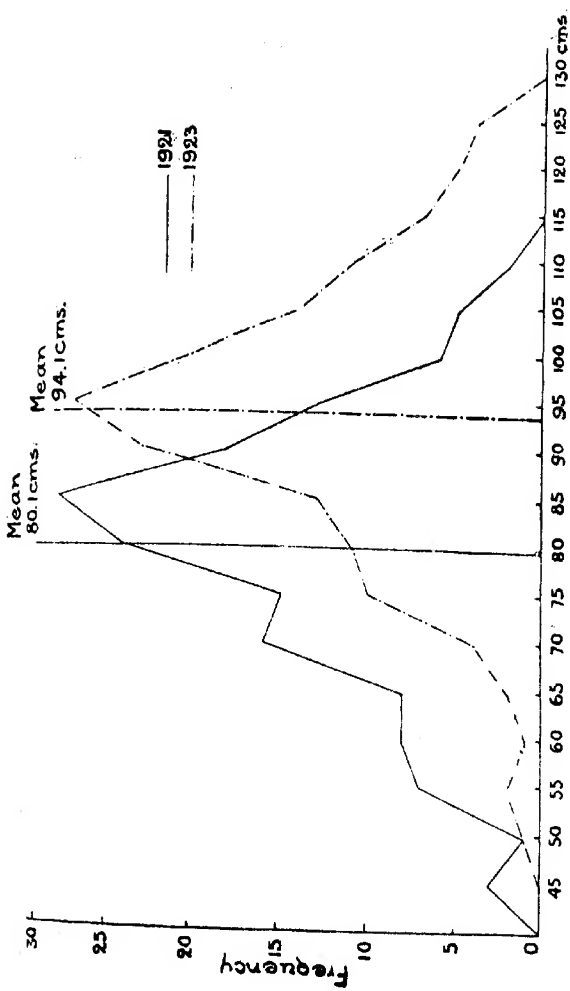

Fig. 4.—Frequency polygons for girth, 1921 and 1923.

Table 7.

Frequency Distribution of Girth for 1923.

Girth. cm.	Frequency.
50	1
55	2
60	1
65	2
70	4
75	10
80	11
85	13
90	23
95	27
100	20
105	14
110	11
115	7
120	5
125	4

The mean girth of the 155 trees in 1921 was 80·1 ± ·74 cm., and in April, 1923, it was 94·1 cm. ± ·79 cm.. The mean had, therefore, increased during the two years by 14·1 cm. or 17·5 per cent. The coefficient of variability in 1921 was 17·0, and in 1923 it was 15·5, a quantity more nearly approaching the values given by Whitby (10) and la Rue (8) for mixed populations (14·8 and 14·0 respectively).

It is to be expected that those trees which had the greatest girth in 1921 will still have the greatest girth in 1923, and that, therefore, the coefficient of correlation between the girths of 1921 and 1923 should approximate + 1. The correlation between the girth measurements of these years is shown in Table 8, and the coefficient of correlation has been calculated to be + ·96 ± ·006. This table has been included in the text to illustrate the form of a correlation table, where a close degree of relationship exists between the characters concerned. It will be noted that the figures are arranged diagonally across the table, and are not scattered sporadically over the whole area of the table as is the case where the relationship is not marked, *cf.* Table 38.

Table 8.

Correlation Girth, 1921, and Girth, 1923.

Girth, 1921, in Centimetres.		Girth, 1923, in Centimetres.																	Total.
		50	55	60	65	70	75	80	85	90	95	100	105	110	115	120	125		
45	..	1	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	..	3
50	..	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	..	1
55	..	.	.	1	2	1	2	1	.	.	.	.	.	.	.	.	.	..	7
60	..	.	.	.	.	.	5	2	1	.	.	.	.	.	.	.	.	..	8
65	..	.	.	.	.	2	2	2	1	1	.	.	.	.	.	.	.	..	8
70	..	.	.	.	.	.	1	5	5	4	1	.	.	.	.	.	.	..	16
75	..	.	.	.	.	.	.	1	6	4	4	.	.	.	.	.	.	..	15
80	..	.	.	.	.	.	.	.	.	13	9	2	.	.	.	.	.	..	24
85	..	.	.	.	.	.	.	.	.	1	12	11	2	1	1	.	.	..	28
90	..	.	.	.	.	.	.	.	.	.	1	7	8	1	1	.	.	..	18
95	..	.	.	.	.	.	.	.	.	.	.	.	4	7	2	.	.	..	13
100	..	.	.	.	.	.	.	.	.	.	.	.	.	2	2	3	.	..	7
105	..	.	.	.	.	.	.	.	.	.	.	.	.	.	1	2	2	..	5
110	..	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	..	2
Total	..	1	2	1	2	4	10	11	13	23	27	20	14	11	7	5	4		155

Girth, 1921.

Mean.	Standard Deviation.
80·1 cm.	13·69 cm.

Girth, 1923.

Mean.	Standard Deviation.
94·10 cm.	14·56 cm.

Coefficient of correlation = + ·95 ± ·006.

Increase in Girth.

The increase in the girth has been calculated as a percentage of the 1921 girth. It was found that Tree 136 shows the smallest increase in girth, namely, 3·5 per cent., and that Tree 14 shows the greatest, 42·6 per cent. The frequency distribution is given in Table 9, and the frequency curve in Fig. 5.

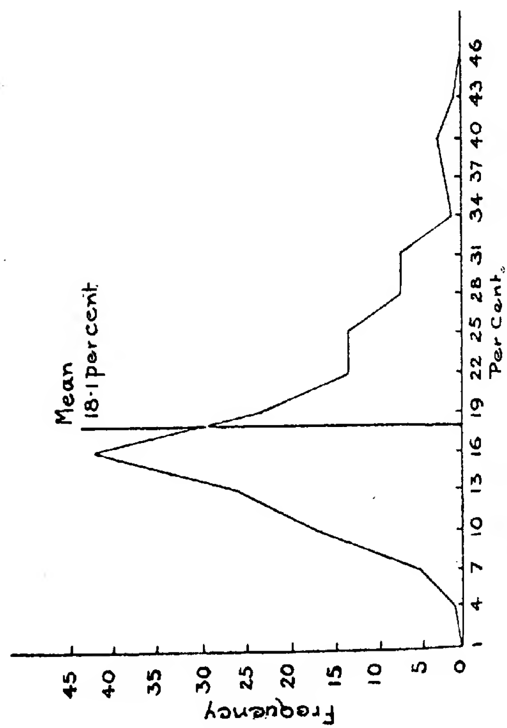

Fig. 5.—Frequency polygon for percentage increase in girth.

Table 9.

Frequency Distribution of Percentage Increases in Girth.

Percentage Increase.	Frequency.	Percentage Increase.	Frequency.
2·5 – 5·4 ..	1	23·5 – 26·4 ..	10
5·5 – 8·4 ..	5	26·5 – 29·4 ..	7
8·5 – 11·4 ..	17	29·5 – 32·4 ..	7
11·5 – 14·4 ..	26	32·5 – 35·4 ..	1
14·5 – 17·4 ..	42	35·5 – 38·4 ..	2
17·5 – 20·4 ..	23	38·5 – 41·4 ..	3
20·5 – 23·4 ..	10	41·5 – 44·4 ..	1

The mean value of these percentage increases in girth is 18·1 $\pm$ ·397, and the coefficient of variability is 40·5. The percentage increase in girth, therefore, shows greater variability than does the actual girth. The relationship between these two characters in this respect resembles the relationship existing between yield and yield increase.

It was shown in the previous Bulletin [4] that no correlation exists between the initial girth and the actual increase in girth. The coefficient of correlation for these characters for the first ten months of the experiment was found to be $-$ ·001 $\pm$ ·053, which is practically zero. The relationship between the same characters for the two years covered by this investigation is represented by a coefficient of correlation of $+$ ·08 $\pm$ ·054 which also closely approximates zero. It may therefore be concluded that the actual increases in girth of the smallest trees are, on the average, equal to the actual increases shown by the largest trees. This indicates a tendency towards an "evening up" in the size of the trees. This tendency is further demonstrated by the fact that the coefficient of variability for the 1923 girths is smaller than that for the 1921 girths (15·5 and 17·0 respectively).

It would appear that, if on the average the smaller trees show actual increases in girth equal to those of the initially larger trees, then the smaller trees must be growing at a proportionately greater rate. This conclusion may be reached by a study of the measurements of girth and percentage increase in girth given by Petch in a paper [7] on "Girth Increment of Hevea brasiliensis," where he records poor growth in the initially largest tree and rapid growth in the initially small trees. The degree of relationship between the size of the trees and the proportional rate of growth may be represented by the coefficient of correlation for the characters girth (in 1921) and the percentage increase in girth (for the two years under

Table 10.

Correlation between Girth, 1921, and Percentage Increase in Girth, 1921–23.

Girth, 1921, in Centimetres.		Percentage Increase in Girth. 4	7	10	13	16	19	22	25	28	31	34	37	40	43		Total.
45	..	.	.	.	.	1	1	.	.	.	.	1	.	.	.	..	3
50	..	.	.	.	.	.	.	.	.	.	1	.	.	.	.	..	1
55	..	.	.	2	.	1	.	.	1	.	.	.	1	2	.	..	7
60	..	.	.	.	.	.	.	2	1	1	2	.	.	1	1	..	8
65	..	1	1	.	.	2	.	1	1	1	.	.	1	.	.	..	8
70	..	.	.	2	1	4	1	1	2	3	2	.	.	.	.	..	16
75	..	.	1	1	3	3	2	1	3	1	.	.	.	.	.	..	15
80	..	.	.	4	6	9	3	2	.	.	.	.	.	.	.	..	24
85	..	.	.	3	8	7	7	1	1	.	1	.	.	.	.	..	28
90	..	.	3	2	2	7	3	.	.	.	1	.	.	.	.	..	18
95	..	.	.	1	4	3	3	1	.	1	.	.	.	.	.	..	13
100	..	.	.	1	1	2	2	1	.	.	.	.	.	.	.	..	7
105	..	.	.	1	1	2	.	.	1	.	.	.	.	.	.	..	5
110	..	.	.	.	.	1	1	.	.	.	.	.	.	.	.	..	2
Total	..	1	5	17	26	42	23	10	10	7	7	1	2	3	1		155

Girth, Increase.		Girth, 1921.	
Mean.	Standard Deviation.	Mean.	Standard Deviation.
18·12 per cent.	7·32 per cent.	80·1 cm.	13·69 cm.

Coefficient of correlation = — ·40 ± 0·46.

observation). The correlation table for these characters is given in Table 10, from which the coefficient of correlation has been calculated to be — ·40 ± ·046. This indicates that the trees which had the *smallest* girth in April, 1921, have made on the average the *greatest* increase in girth in proportion to their initial size, and, conversely, the largest trees have made the smallest proportional increase. These facts may be further illustrated by a classification of the trees into three groups, viz., high, medium, and low, the same principle being employed as for yield. The low group, consisting of trees with girths of less than 70·9 cm. in April, 1921, contains 38 trees; the high group, consisting of trees with girths greater than 89·3 cm. in the same year, contains 37 trees. For purposes of comparison the data concerning these two groups are given in Table 11.

Table 11.

Comparison of Girth Low Group with Girth High Group.

	Number of Trees in Group.	Mean Girth. 1921. cm.	Mean Girth. 1923 cm.	Increase of Mean. cm.	Increase as percentage of 1921 Girth.
Low Group	38	61·7	76·2	14·5	23·4 ± 1·01
High Group	37	96·4	111·2	14·8	15·4 ± ·49

From the foregoing table it is apparent that the mean increase in girth of the large trees is only 0·3 cm. greater than that of the small trees. In proportion, however, to their initial size, the small trees have increased their mean girth measurement by 23·4 per cent. against 15·4 per cent. of the large trees. The difference, 8·0 ± 1·12 per cent., is statistically significant, which indicates that the difference is real, and not due solely to the variable measurements from which the result has been obtained.

This conclusion should at once be compared with that reached for yield and percentage increase in yield in the preceding section.

Latex Vessel Rows.

In determining the number of rows of latex vessels in the various specimens of cortex, difficulties were frequently encountered owing to the presence of interrupted or ill-defined rows, to the branching or anastomosing of rows, and to the variations in visibility of rows in different specimens. Such difficulties in measurements, into which the personal element

enters to a large extent, give rise to errors, commonly known as personal errors. Such characters as girth, cortex thickness, and yield are capable of exact measurement by instruments, and these measurements are consequently not liable to personal errors of a magnitude as great as the error in the determination of the number of latex vessel rows. Precautions were therefore taken to eliminate this error as far as possible; three sections of each specimen of cortex were examined by each of the authors, and the average of the readings was taken as the correct determination of the number of rows of latex vessels present.

Despite the precautions taken, it is improbable that the personal error was eliminated, but it may reasonably be concluded that it was considerably reduced. The presence of this error must be borne in mind when conclusions based on these determinations are considered. At the same time, from the nature of the precautions taken, the conclusions arrived at should not be vitiated to any great extent by the personal error.

In the case of Tree No. 41 an actual error was discovered in the number of latex vessel rows recorded for 1921. Instead of 8 rows, as previously stated, the number is 15. This corrected figure has been applied in all calculations based on data for the 12 months, 1921–22, and the results obtained do not materially differ from those published in Bulletin 55.

In Cortex at 2 Feet.

The mean number of latex vessel rows in the cortex of the 155 trees at 2 feet in 1921 was $11 \cdot 3 \pm \cdot 158$. In 1923 the mean number had increased to $19 \cdot 7 \pm \cdot 257$. The frequency distribution of the numbers of rows in 1923 is given in Table 12. During the two years the mean number of rows had increased by $8 \cdot 4 \pm \cdot 302$, *i.e.*, by 75 per cent. It has previously been pointed out [4] that the frequency curve in 1921 was approximately symmetrical and departed from the normal curve to a smaller extent than did the curve given by Bobilioff [2] for this character. In 1923 the curve is again approximately normal, and differs but slightly from the 1921 curve (see Fig. 6). It has been calculated that the skewness for the 1921 curve was $- \cdot 112 \pm \cdot 066$, and for the 1923 curve $+ \cdot 114 \pm \cdot 066$. The curve, in each case, can therefore be considered as normal. From the data given by Bobilioff [2] the skewness of his curve has been calculated to be $\cdot 69 \pm \cdot 04$, which shows a considerable difference from the results obtained from the present plot in either year.

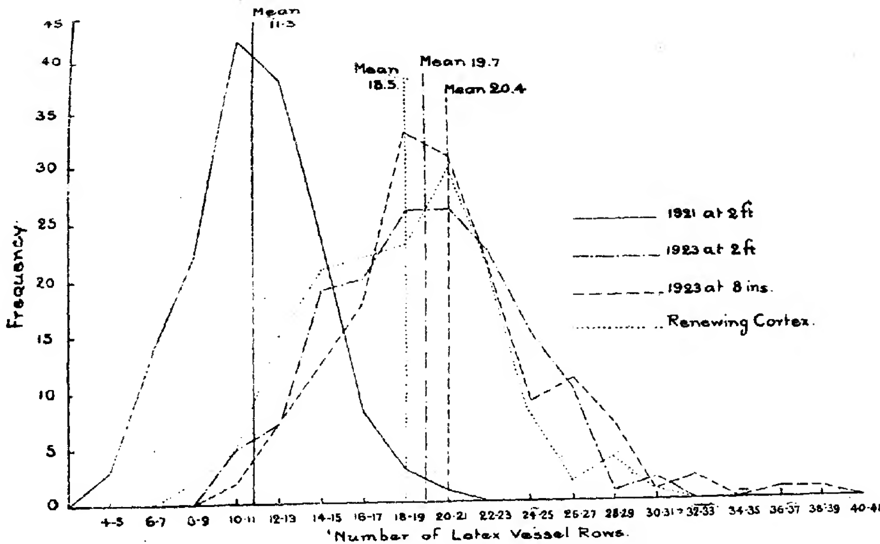

Fig. 6.—Frequency polygons for number of latex vessel rows at 2 feet, 1921 and 1923, at 8 inches, 1923, and in renewing cortex.

Table 12.

Frequency Distribution of Number of Latex Vessel Rows at 2 Feet in 1923.

Number of Rows.	Frequency.
10–11	5
12–13	7
14–15	19
16–17	20
18–19	26
20–21	26
22–23	22
24–25	15
26–27	10
28–29	1
30–31	2
32–33	0
34–35	0
36–37	1
38–39	1

There is a possibility of an annual variation in the number of latex vessel rows in the cortex. If there is a great variation in the rate of formation of new latex vessel rows, it is not unlikely that trees with few rows in one year may have numerous rows in a succeeding year. The relationship between the numbers of rows present in 1921 and in 1923 is shown in Table 13, from which a coefficient of correlation of $+ \cdot 54 \pm \cdot 039$ has been obtained. This indicates that on the average the trees which had the largest numbers of rows in 1921 again have the largest numbers in 1923. It will be noted that this coefficient of correlation is less than those found for Yield, 1921–22 and 1922–23, and for Girth, 1921 and 1923. This would indicate that the number of latex vessel rows is not so constant a character as are Girth and Yield.

Increase in Number of Latex Vessel Rows at 2 Feet.

Though the mean number of latex vessel rows has increased during the two years under review, the increase has, by no means, been uniform throughout the plot. No tree had fewer rows in 1923 than in 1921, though two trees showed no increase. The greatest increase was 23 rows. It is evident, therefore, that the trees have exhibited great variability as regards the number of rows which they have added during these two years. The variation which occurs in the rate of formation of new rows is clearly shown in Table 14, in which the increase is expressed as a percentage of the number of rows present in 1921. This table is represented graphically in Fig. 7.

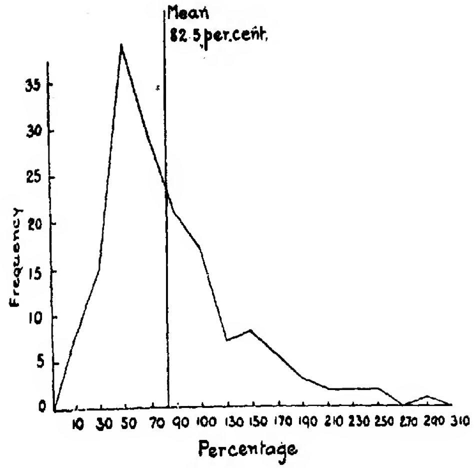

Fig. 7.—Frequency polygon for percentage increase in number of latex vessel rows at 2 feet.

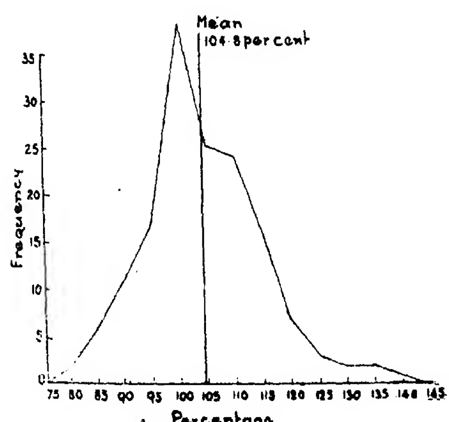

Fig. 8.—Frequency polygon for number of latex vessel rows at 8 inches as a percentage of the number at 2 feet.

Table 13.

Correlation between Number of Latex Vessel Rows in 1921 and Number of Latex Vessel Rows in 1923 at 2 Feet.

Number of Latex Vessel Rows, 1923.		Number of Latex Vessel Rows, 1921. 5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21		Total.
10–11	..	.	1	2	.	1	.	1	.	.	.	.	.	.	.	.	.	.	..	5
12–13	..	.	.	.	.	3	1	2	1	.	.	.	.	.	.	.	.	.	..	7
14–15	..	2	1	2	3	3	5	2	.	.	1	.	.	.	.	.	.	.	..	19
16–17	..	.	.	1	2	2	2	3	6	3	.	1	.	.	.	.	.	.	..	20
18–19	..	1	.	1	.	4	6	3	6	2	2	.	1	.	.	.	.	.	..	26
20–21	..	.	1	1	.	.	3	4	7	.	5	4	.	.	1	.	.	.	..	26
22–23	..	.	.	2	2	2	4	1	5	.	2	1	3	.	.	.	.	.	..	22
24–25	..	.	.	2	.	.	3	2	1	4	.	1	1	.	1	.	.	.	..	15
26–27	..	.	.	.	.	.	.	.	.	2	1	4	1	2	.	.	.	.	..	10
28–29	..	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	..	1
30–31	..	.	.	.	.	.	.	.	.	.	1	.	.	.	1	.	.	.	..	2
32–33	..	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	..	0
34–35	..	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	..	1
36–37	..	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	..	1
38–39	..	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	..	
Total	..	3	3	11	7	15	24	18	27	11	12	12	6	2	3	0	0	1	..	155

Number of Latex Vessel Rows, 1921.
$\overbrace{\text{Mean. 11·3 rows} \qquad \text{Standard Deviation. 2·91 rows}}$

Number of Latex Vessel Rows, 1923.
$\overbrace{\text{Mean. 19·7 rows} \qquad \text{Standard Deviation. 4·74 rows}}$

Coefficient of correlation $= + \cdot 54 \pm \cdot 039$.

Table 14.

Frequency Distribution of Percentage Increases in Number of Latex Vessel Rows at 2 Feet.

Percentage Increase.	Frequency.
0– 19	8
20– 39	15
40– 59	39
60– 79	29
80– 99	21
100–119	17
120–139	7
140–159	8
160–179	1
180–199	3
200–219	2
220–239	2
240–259	2
260–279	0
280–299	1

It will be seen from Fig. 7 that more trees fall into the 50 per cent. group than in any other. The mean percentage increase may be calculated from Table 14 to be $82 \cdot 5 \pm 2 \cdot 80$ per cent. The curve is therefore skewed towards the lower end of the range (skewness $= + \cdot 73$).

Since there is a considerable variation in the rate of increase in the number of latex vessel rows, it is necessary to determine whether the trees which had the largest number of rows in 1921 have shown the greatest increase, *i.e.*, whether there is any relationship existing between the initial number of rows and the rate of increase. In Table 15 is shown the relationship between the number of rows of latex vessels in 1921 and the percentage increase in the number of latex vessel rows during the two years. The coefficient of correlation for these characters has been calculated to be $- \cdot 51 \pm \cdot 04$. From this coefficient it is evident that on the average the trees which had the *smallest* number of rows in 1921 have made the *greatest* proportional increase, and those trees which had the largest number of rows initially have made the smallest increases.

This fact may be further demonstrated by dividing the trees into three groups as was done for yield. Trees which in 1921 had less than 10 rows constitute the Low Group, and those with more than 13 rows form the High Group. A comparison of these groups, consisting of 39 and 36 trees, respectively, is given in Table 16.

Table 15.

Correlation between Number of Latex Vessel Rows in 1921 and Percentage Increase in Number of Latex Vessel Rows, 1921–23, at 2 Feet.

Number of Latex Vessel Rows, 1921.	Percentage Increase in Number of Latex Vessel Rows. 10	30	50	70	90	110	130	150	170	190	210	230	250	270	290	Total.
5 ..	.	.	.	.	.	.	.	.	.	1	1	.	.	.	1	3
6 ..	.	.	.	1	.	.	1	.	.	.	.	1	.	.	.	3
7 ..	.	.	2	.	.	2	1	1	.	1	1	1	2	.	.	11
8 ..	.	.	.	3	.	2	.	.	1	1	.	.	.	.	.	7
9 ..	.	1	3	5	.	4	.	2	.	.	.	.	.	.	.	15
10 ..	.	1	5	2	6	3	4	3	.	.	.	.	.	.	.	24
11 ..	3	2	3	3	4	2	1	.	.	.	.	.	.	.	.	18
12 ..	1	3	9	7	5	1	.	1	.	.	.	.	.	.	.	27
13 ..	.	3	2	.	4	2	.	.	.	.	.	.	.	.	.	11
14 ..	1	2	6	1	1	1	.	.	.	.	.	.	.	.	.	12
15 ..	1	1	4	4	1	.	.	1	.	.	.	.	.	.	.	12
16 ..	1	1	3	1	.	.	.	.	.	.	.	.	.	.	.	6
17 ..	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	2
18 ..	1	1	.	1	.	.	.	.	.	.	.	.	.	.	.	3
19 ..	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
20 ..	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
21 ..	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	1
Total ..	8	15	39	29	21	17	7	8	1	3	2	2	2	0	1	155

Number of Latex Vessel Rows, 1921.		Percentage Increase in Number of Latex Vessel Rows.	
Mean.	Standard Deviation.	Mean.	Standard Deviation.
11·28	2·91 rows	82·5	51·6 rows

Coefficient of correlation = — ·51 ± ·04.

Table 16.

Comparison of Latex Vessel Row Low Group with Latex Vessel Row High Group.

	Number of Trees in Group.	Mean Number of Latex Vessel Rows. 1921.	Mean Number of Latex Vessel Rows. 1923.	Increase of Mean.	Mean Increase as Percentage of 1921 Number.
Low Group ..	39 ..	7·7 ..	16·9 ..	9·2 ..	126 ± 7·36
High Group..	36 ..	15·4 ..	23·5 ..	8·1 ..	53 ± 3·16

From the above table it is evident that the mean number of latex vessel rows of the Low Group has increased by 9·2, whereas that of the High Group has increased by 8·1. The difference here is very small. The mean percentage increase of the Low Group is, however, 126 ± 7·36 and that of the High Group 53 ± 3·16. This difference 73 ± 8·01 per cent. is large, and should be taken as significant. Consequently, trees in the Low Group have produced proportionately more latex vessel rows than trees of the High Group.

Here then, as in girth, the Low Group shows a greater percentage increase than the High Group, and in this, both these characters differ from yield.

Number of Latex Vessel Rows at 8 Inches.

The frequency distribution of the number of latex vessel rows in the cortex at 8 inches from the ground is given in Table 17, and represented graphically in Fig. 6.

Table 17.

Frequency Distribution of Number of Latex Vessel Rows at 8 Inches in 1923.

Rows.	Frequency.	Rows.	Frequency.
10–11 ..	2	26–27 ..	11
12–13 ..	7	28–29 ..	7
14–15 ..	11	30–31 ..	1
16–17 ..	18	32–33 ..	2
18–19 ..	33	34–35 ..	0
20–21 ..	31	36–37 ..	1
22–23 ..	21	38–39 ..	1
24–25 ..	9		

The mean number of latex vessel rows in the cortex at 8 inches was found to be 20·4 ± ·258. This number is greater than that found for the cortex at 2 feet by ·7 ± ·36, a quantity which is statistically insignificant. In some trees there were more rows in the cortex at 8 inches than at 2 feet, the greatest increase being 8 rows; other trees showed fewer rows at 8 inches than at 2 feet, the greatest decrease being 4 rows. The relative values of these differences are best shown when the number of latex vessel rows at 8 inches is expressed as a percentage of the number at 2 feet. (Table 18 and Fig. 8.)

Table 18.

Frequency Distribution of Number of Latex Vessel Rows at 8 Inches as a Percentage of the Number at 2 Feet.

Percentage.		Frequency.	Percentage.		Frequency.
77·5– 82·4	..	2	117·5–122·4	..	7
82·5– 87·4	..	6	122·5–127·4	..	3
87·5– 92·4	..	11	127·5–132·4	..	2
92·5– 97·4	..	17	132·5–137·4	..	2
97·5–102·4	..	38	137·5–142·4	..	1
102·5–107·4	..	25	....		
107·5–112·4	..	24	....		
112·5–117·4	..	16	177·5–182·4	..	1

It will be seen from the above table that the greatest number of trees fall into the group 97·5 — 102·4 per cent., the mid point of which is 100. This class contains all the trees in which the number of rows in the cortex at 8 inches does not differ from the number in the cortex at 2 feet by more than 2½ per cent. The mean percentage has been calculated to be 104·8 ± ·67.

It is evident, therefore, that the mean number of latex vessel rows in the cortex at 2 feet and at 8 inches above ground level is approximately the same. Any increase in yield obtained as the tapping cut descends the tree cannot, therefore, be ascribed solely to the presence of an increasing number of latex vessel rows on descending. This will again be referred to in Part III.

Cortex Thickness.

The frequency distribution of cortex thickness in 1923 at 2 feet from ground level is given in Table 19, and represented graphically in Fig. 9.

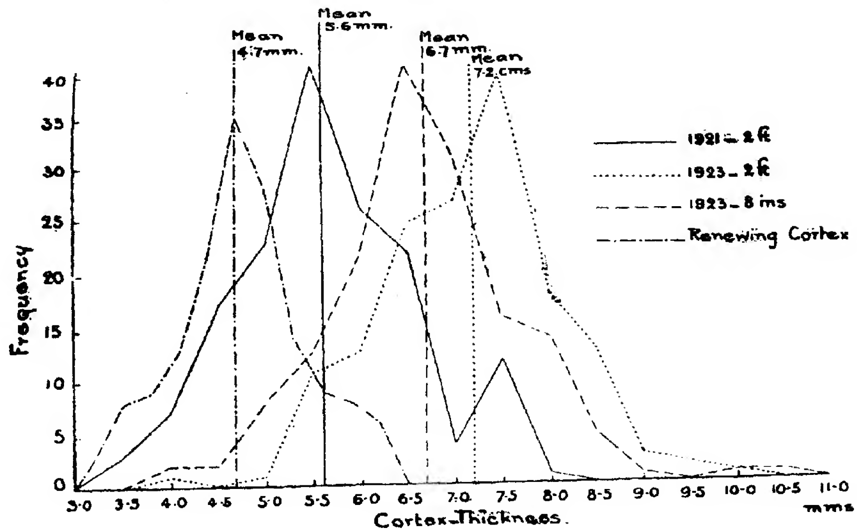

Fig. 9.—Frequency polygon for cortex thickness at 2 feet, 1921 and 1923, at 8 inches, 1923, and in renewing cortex.

Table 19.

Frequency Distribution of Cortex Thickness at 2 Feet in 1923.

Thickness. mm.		Frequency.	Thickness. mm.		Frequency.
4·0	..	1	7·5	..	39
4·5	..	0	8·0	..	18
5·0	..	1	8·5	..	13
5·5	..	11	9·0	..	3
6·0	..	13	9·5	..	2
6·5	..	25	10·0	..	1
7·0	..	27	10·5	..	1

The mean thickness of the cortex at 2 feet from the ground of the 155 trees was 5·64 ± ·051 mm. in April, 1921. In April, 1923, the mean thickness was 7·18 ± ·054 mm., which represents an increase of 1·54 mm. or 27·3 per cent.

That the trees which had the greatest cortex thickness in 1921 had also the greatest thickness in 1923 may be seen from Table 20. From this table the coefficient of correlation has been calculated to be + ·86 ± ·014. Cortex thickness is therefore a stable character.

The frequency distribution of cortex thickness in 1923 at 8 inches above ground level is given in Table 21, and is represented graphically in Fig. 9. The similarity of the curves in Fig. 9 is marked, and indicates no change in the variability of the character.

Table 21.

Frequency Distribution of Cortex Thickness at 8 Inches in 1923.

Thickness. mm.		Frequency.	Thickness. mm.		Frequency.
4·0	..	2	7·5	..	16
4·5	..	2	8·0	..	14
5·0	..	8	8·5	..	5
5·5	..	13	9·0	..	1
6·0	..	22	9·5	..	0
6·5	..	40	10·0	..	1
7·0	..	31			

At 8 inches from the ground the mean thickness of the cortex in 1923 was 6·65 ± ·053 mm., which is ·63 ± ·076 mm., or 8·8 per cent. less than that at 2 feet. The difference

Table 20.

Correlation between Cortex Thickness, 1921, and Cortex Thickness, 1923, at 2 Feet.

Cortex Thickness, 1923, in Millimetres.	Cortex Thickness, 1921, in Millimetres. 3·5	4·0	4·5	5·0	5·5	6·0	6·5	7·0	7·5	8·0	Total.
4·0 ..	1	.	.	.	.	.	.	.	.	.	1
4·5 ..	.	.	.	.	.	.	.	.	.	.	0
5·0 ..	1	.	.	.	.	.	.	.	.	.	1
5·5 ..	1	4	5	1	.	.	.	.	.	.	11
6·0 ..	.	1	5	6	1	.	.	.	.	.	13
6·5 ..	.	2	6	8	7	2	.	.	.	.	25
7·0 ..	.	.	1	4	14	7	1	.	.	.	27
7·5 ..	.	.	.	4	17	11	6	1	.	.	39
8·0 ..	.	.	.	.	1	6	9	.	2	.	18
8·5 ..	.	.	.	.	.	.	5	2	6	.	13
9·0 ..	.	.	.	.	.	.	1	1	.	1	3
9·5 ..	.	.	.	.	.	.	.	.	2	.	2
10·0 ..	.	.	.	.	.	.	.	.	1	.	1
10·5 ..	.	.	.	.	.	.	.	.	1	.	1
Total ..	3	7	17	23	40	26	22	4	12	1	155

Thickness Cortex, 2 Feet, 1923.

Mean.	Standard Deviation.
7·18 mm.	1·00 mm.

Thickness Cortex, 2 Feet, 1921.

Mean.	Standard Deviation.
5·64 mm.	·947 mm.

Coefficient of correlation = + ·86 ± ·014.

·63 mm. is more than 8 times as great as its probable error, and may be considered to be significant. On the average, therefore, the thickness of the cortex is greater at 2 feet than at 8 inches. All measurements refer to the thickness of the living cortex excluding the dead bark scales. It is possible, therefore, that the greater thickness at 2 feet is due to the more rapid scaling of the bark at 8 inches. At the same time it should be pointed out that the root cortex is thinner than the stem cortex, and the influence of the root system on the lower portions of the stem would, therefore, tend toward the formation of thinner cortex in this region.

Increase in Cortex Thickness.

The increase in cortex thickness at 2 feet is best considered when expressed as a percentage of the initial thickness in 1921. An increase in cortex thickness (say, 1 mm.) made by a thin cortex represents a proportionately greater increase than does the same amount made by a thick cortex. The proportional increase in cortex thickness has been calculated for each tree, and the frequency distribution is given in Table 22, and represented graphically in Fig. 10.

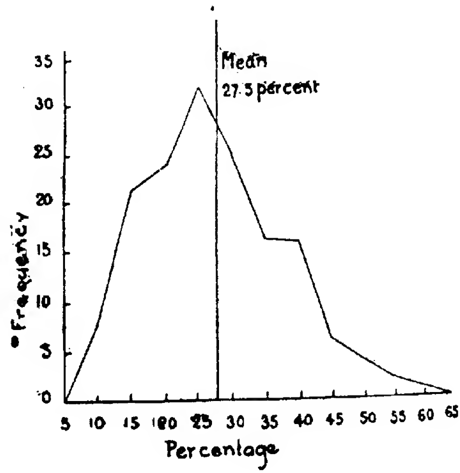

Fig. 10.—Frequency polygon for percentage increase in cortex thickness at 2 feet.

Table 22.

Frequency Distribution of Percentage Increases in Cortex Thickness.

Percentage Increase.	Frequency.
7·5–12·4	8
12·5–17·4	21
17·5–22·4	24
22·5–27·4	32
27·5–32·4	25
32·5–37·4	16
37·5–42·4	16
42·5–47·4	6
47·5–52·4	4
52·5–57·4	2
57·5–62·4	1

It may be calculated from Table 22 that the mean increase in cortex thickness is 27·5 ± ·572 per cent. From Fig. 10 it will be seen that the approximate mode is at 25 per cent., *i.e.*, less than the mean, and consequently the curve is skewed slightly towards the lower limit of the range.

The coefficient of variation for the percentage increase in cortex thickness is 38·4, whereas the coefficient of variation for actual cortex thickness at 2 feet is 13·9. The variation in increase of cortex thickness is greater than the variation shown in the actual measurements of thickness itself.

Is there any relationship between the initial cortex thickness and the percentage increase of cortex thickness? Have those trees, which originally had the thickest cortex at 2 feet, increased by the largest amount in proportion to their initial thickness? These questions may be answered by means of the coefficient of correlation for these characters, for which the correlation table is given in Table 23. The coefficient of correlation has been calculated to be — ·47 ± ·042. This indicates that, on the average, the cortices which were thickest in 1921 have increased by smaller amounts, in proportion to their initial thickness, than have the initially thinner cortices.

If the trees are divided into three classes according to the thickness of their cortex in 1921, it will be found that 39 trees had cortices thicker than 6·2 mm., and 36 trees, cortices thinner than 5·0 mm. The remaining trees have cortex thickness approximating the mean measurement for the plot. The mean measurements for the two extreme classes are given in able 24.

Table 23.

Correlation between Cortex Thickness, 1921, and Percentage Increase in Cortex Thickness, 1921–23, at 2 Feet.

Cortex Thickness. mm.		Percentage Increase in Cortex Thickness. 10	15	20	25	30	35	40	45	50	55	60		Total.
3·5	..	.	1	.	.	.	1	.	1	.	.	.	..	3
4·0	..	.	.	.	.	2	.	1	1	1	1	1	..	7
4·5	..	.	2	1	1	1	5	2	3	1	1	.	..	17
5·0	..	.	1	3	6	2	3	5	1	2	.	.	..	23
5·5	..	.	4	5	10	10	6	5	.	.	.	.	..	40
6·0	..	2	5	5	7	5	1	1	.	.	.	.	..	26
6·5	..	2	4	7	5	3	.	1	.	.	.	.	..	22
7·0	..	1	.	.	2	1	.	.	.	.	.	.	..	4
7·5	..	3	3	3	1	1	.	1	.	.	.	.	..	12
8·0	..	.	1	.	.	.	.	.	.	.	.	.	..	1
Total	..	8	21	24	32	25	16	16	6	4	2	1		155

Cortex Thickness, 1921.		Percentage Increase in Cortex Thickness, 1921–23, 2 Feet.	
Mean.	Standard Deviation.	Mean.	Standard Deviation.
5·64 mm.	·947 mm.	27·52 per cent.	10·55 per cent.

Coefficient of correlation = — ·47 ± ·042.

Table 24.

Comparison of Cortex Thickness Low Group with Cortex Thickness High Group.

	Mean Cortex Thickness. 1921.	Mean Cortex Thickness. 1923.	Difference.	Mean Percentage Increase in Thickness.
	mm.	mm.	mm.	
Low Group ..	4·4 ..	6·0 ..	1·6 ..	36·2 ± 1·24
High Group ..	6·9 ..	8·3 ..	1·4 ..	20·9 ± ·79

Though the mean cortex thickness of both groups had increased by approximately the same amount, the trees with the thinner cortex have increased their measurements by 36·2 ± 1·24 per cent., whereas the increase of the trees with the thicker cortex is 20·9 ± ·79 per cent. The difference 15·3 ± 1·47 per cent. is 10·4 times as large as its probable error, and is consequently significant.

It should be noted that the relationship between cortex thickness and percentage increase in cortex thickness is similar to that between girth and percentage increase of girth, and to that between number of latex vessel rows and percentage increase.

Renewing Cortex.

In estate practice tapping is begun at a height of 2 feet, and is continued down to the base of the tree. From this point the cut is changed to the other side of the tree, and again is continued down to the base. When there is no untapped cortex left in this region, tapping has to be carried out on cortex which has been previously tapped, and naturally the cut is placed on that portion of the cortex which has had the longest time for regeneration. This regenerated cortex is in practice termed "renewing cortex," and on its character will depend the future yield of the tree. The period allowed for this regeneration is usually 8 to 10 years, and depends on the system of tapping adopted. The time necessary for complete regeneration has been arrived at empirically, generally on estate experience of the rate of increase in thickness of the renewing cortex, or of the yields obtained from renewing cortex of various ages. Exact information is therefore desirable as to the rate of renewal, the character of the renewing cortex, its similarity to the untapped cortex, and its yield as compared with that of the untapped cortex preceding it. This last point cannot yet be dealt with in the present experiment, as tapping will not be commenced on the renewing cortex till about 1929. The other points, however, are discussed below. The specimens of renewing cortex examined here had had two years for regeneration.

Thickness.

The frequency distribution of the measurements of the thickness of the renewing cortex at 2 feet in April, 1923, are given in Table 25, and represented graphically in Fig. 9.

Table 25.

Frequency Distribution of Renewing Cortex Thickness Measurements.

Thickness mm.	Frequency.	Thickness. mm.	Frequency.
3·10–3·39 ..	3	4·90–5·19 ..	28
3·40–3·69 ..	8	5·20–5·49 ..	14
3·70–3·99 ..	9	5·50–5·79 ..	9
4·00–4·29 ..	13	5·80–6·09 ..	8
4·30–4·59 ..	22	6·10–6·39 ..	6
4·60–4·89 ..	35		

The mean thickness of the renewing cortex was 4·74 ± ·037 mm., the greatest thickness being 6·3 mm., and the least 3·2 mm. The coefficient of variability (14·3) is similar in magnitude to that of the untapped cortex at 2 feet (13·9). In Fig. 9 the resemblance between the frequency polygon for the renewing cortex and those for the untapped cortex at 2 feet and at 8 inches will be noticed. It will also be seen that the renewing cortex has not yet attained the thickness of the untapped cortex for 1921.

The renewing cortex thickness expressed as a percentage of untapped cortex at 2 feet in 1923 is given in Table 26. From this it will be seen that the lowest nine trees have renewing cortex of half the thickness of their untapped cortex, and the highest tree has the former approximately equal to the latter.

Table 26.

Frequency Distribution of Renewing Cortex Thickness as a Percentage of Untapped Cortex Thickness.

Percentage.	Frequency.	Percentage.	Frequency.
47·5–52·4 ..	9	72·5–77·4 ..	16
52·5–57·4 ..	20	77·5–82·4 ..	10
57·5–62·4 ..	26	82·5–87·4 ..	7
62·5–67·4 ..	33	87·5–92·4 ..	5
67·5–72·4 ..	28	92·5–97·4 ..	1

The mean of the foregoing frequency distribution is 66·8 ± ·54 per cent., and this indicates that on the average the renewing cortex, after two years' growth, has attained two-thirds of the thickness of the adjacent untapped cortex.

Table 27.

Correlation between Untapped Cortex Thickness, 1923, and Renewing Cortex Thickness, 1923, at 2 Feet.

Thickness of Renewing Cortex in Millimetres.	Untapped Cortex Thickness in Millimetres. 4·0	4·5	5·0	5·5	6·0	6·5	7·0	7·5	8·0	8·5	9·0	9·5	10·0	10·5	Total.
3·2 ..	.	.	.	2	1	.	.	.	.	.	.	.	..	.	3
3·5 ..	1	.	.	2	3	1	1	.	.	.	.	.	.	.	8
3·8 ..	.	.	1	1	.	2	1	3	1	.	.	.	.	.	9
4·1 ..	.	.	.	2	2	3	.	3	3	.	.	.	.	.	13
4·4 ..	.	.	.	1	1	4	5	6	3	2	.	.	.	.	22
4·7 ..	.	.	.	2	2	7	7	10	2	3	1	.	1	.	35
5·0 ..	.	.	.	1	3	3	8	8	3	.	.	2	.	.	28
5·3 ..	.	.	.	.	1	2	1	3	3	2	2	.	.	.	14
5·6 ..	.	.	.	.	.	1	.	4	1	3	.	.	.	.	9
5·9 ..	.	.	.	.	.	1	2	.	2	2	.	.	.	1	8
6·2 ..	.	.	.	.	.	1	2	2	.	1	.	.	.	.	6
Total ..	1	0	1	11	13	25	27	39	18	13	3	2	1	1	155

Thickness, Renewing Cortex.		Thickness, Untapped Cortex at 2 Feet, 1923.	
Mean.	Standard Deviation.	Mean.	Standard Deviation.
4·74 mm.	·681 mm.	7·18 mm.	1·00 mm.

Coefficient of correlation = + ·42 ± ·045.

The relationship between the thickness of untapped cortex and of renewing cortex is shown in Table 27, from which a coefficient or correlation of $+ \cdot 42 \pm \cdot 045$ was obtained. This indicates that the trees with thick untapped cortex tend to produce a thick renewing cortex. This is somewhat to be expected, as it has already been shown that those trees which had the thickest cortices in 1921 had on the average the thickest cortices in 1923. It would appear evident, therefore, that thickness of cortex is an inherent character, which determines not only the thickness of the untapped cortex, but also that of the renewing cortex.

Number of Latex Vessel Rows.

The number of latex vessel rows found in the renewing cortex of each tree is given in Table 1. The frequency distribution for this character is given in Table 28, and represented graphically in Fig. 6.

Table 28.

Frequency Distribution of the Number of Latex Vessel Rows in Renewing Cortex.

Number of Latex Vessel Rows.	Frequency.	Number of Latex Vessel Rows.	Frequency.
8–9 ..	2	24–25 ..	8
10–11 ..	5	26–27 ..	2
12–13 ..	15	28–29 ..	4
14–15 ..	21	30–31 ..	1
16–17 ..	22	....	
18–19 ..	23	....	
20–21 ..	30		
22–23 ..	21	40–41 ..	1

It will be noticed that there is one outstanding tree (Tree No. 41) with 41 rows. This tree has 10 rows more than the next best tree, and 22 more than the average (the mean being $18 \cdot 6 \pm \cdot 249$ rows). The polygon representing the frequency distribution (Fig. 6) closely resembles those for the number of rows at 2 feet and at 8 inches in the untapped cortex.

The mean number of rows of latex vessels in the untapped cortex at 2 feet in 1923 was $19 \cdot 7 \pm \cdot 257$, which is only $1 \cdot 1 \pm \cdot 36$ greater than the mean number in the renewing cortex. This quantity, however, is not statistically significant, and it may, therefore, be concluded that the mean number of latex vessel rows in the renewing cortex, after two years' regeneration, is equal to that of the untapped cortex.

The process of renewal may, however, result in the formation of a renewed cortex differing considerably from the untapped cortex, and any change would probably affect the number of latex vessel rows present. It is therefore of interest to determine whether those trees which had the greatest number of latex vessel rows in the untapped cortex maintain this position in regard to their renewing cortex. The coefficient of correlation between the number of latex vessel rows in the untapped cortex at 2 feet, and in the renewing cortex at 2 feet in 1923 (Table 29), is $+ \cdot 69 \pm \cdot 028$ which indicates a decided relationship between these characters. The trees, which on the average have the greatest number of latex vessel rows in the untapped cortex, also have the greatest number in the renewing cortex.

Evidently, the number of latex vessel rows is an inherent character. Those trees which had the greatest number in 1921 have the greatest number in 1923 and also have the greatest number in the renewing cortex, the number being determined by the character.

PART II.

It has already been shown that considerable variation exists in the yielding capacity of the trees under investigation. Further those trees, which gave the highest yields during the first year of tapping, have on the average given the highest yields during the second year, and similarly with girth, cortex thickness, and number of latex vessel rows in the cortex at 2 feet above ground level. It has also been established for the first year of tapping that the trees giving the highest yields are also those with the greatest girth, most numerous latex vessel rows, and thickest cortex. In other words the character yield is interrelated with the characters—girth, number of latex vessel rows, and cortex thickness. The question naturally arises as to whether the relationships established for the first year of tapping still hold good for the second year.

It has also been shown that during the two years of tapping some trees have increased in cortex thickness, girth, &c., by proportionately greater amounts than have other trees. Have those trees which have shown the greatest proportionate increase in girth, cortex thickness, &c., also shown the greatest proportionate increase in yield ?

Table 29.

Correlation between Number of Latex Vessel Rows in Untapped Cortex and Number of Latex Vessel Rows in Renewing Cortex at 2 Feet in 1923.

Number of Latex Vessel Rows in Untapped Cortex.	Number of Latex Vessel Rows in Renewing Cortex. 9–10	11–12	13–14	15–16	17–18	19–20	21–22	23–24	25–26	27–28	29–30	31–32	33–34	35–36	37–38	39–40	41–42	Total.
10–11 ..	.	3	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	5
12–13 ..	1	2	1	2	1	.	.	.	.	.	.	.	.	.	.	.	.	7
14–15 ..	2	1	2	8	3	3	.	.	.	.	.	.	.	.	.	.	.	19
16–17 ..	.	.	5	4	2	5	3	.	1	.	.	.	.	.	.	.	.	20
18–19 ..	.	.	4	6	6	7	2	1	.	.	.	.	.	.	.	.	.	26
20–21 ..	.	2	1	3	7	1	10	1	.	1	.	.	.	.	.	.	.	26
22–23 ..	.	1	1	1	4	7	4	3	1	.	.	.	.	.	.	.	.	22
24–25 ..	.	.	.	.	3	1	5	4	1	.	1	.	.	.	.	.	.	15
26–27 ..	.	.	.	.	.	3	.	3	.	4	.	.	.	.	.	.	.	10
28–29 ..	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	1
30–31 ..	.	.	.	.	.	1	.	1	.	.	.	.	.	.	.	.	.	2
32–33 ..	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
34–35 ..	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0
36–37 ..	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	1
38–39 ..	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1
Total ..	3	9	16	24	26	29	24	13	3	5	1	1	0	0	0	0	1	155

Number of Latex Vessel Rows in Untapped Cortex, 2 Feet, 1923.		Number of Latex Vessel Rows in Renewing Cortex.	
Mean.	Standard Deviation.	Mean.	Standard Deviation.
19·7 rows	4·74 rows.	18·6 rows	4·59 rows

Coefficient of correlation = + ·69 ± ·028.

The following pages are devoted to the elucidation of such problems. Definite information on these points will be of value in the selection of best yielding trees, and may have some influence on general estate practice.

YIELD.

The coefficient of correlation between yield for 1921–22 and yield for 1922–23 is + ·83 ± ·017. This indicates that generally the high-yielding trees of 1921–22 are also the high-yielding trees of 1922–23, and the low-yielding trees continue to give low yields. In so far as yield may be termed a physiological function of the tree—it is, indeed, a response to the stimulus of wounding—it may be treated as a character of the tree, and the constancy exhibited by it for the two years under review is good evidence as to its inherent nature.

Certain relationships were established between yield and other characters in 1921–22 in a previous publication [4], and for convenience these are tabulated below, and may be compared with the corresponding relationships determined for 1922–23:—

Table 30.

Coefficients of Correlation between Yield, 1922–23, and Other Characters.

Other Characters.	Coefficients, 1921–22.	Coefficients, 1922–23.
Yield, 1921–22 ..	—	.. + ·83 ± ·017
Girth, 1923 ..	+ ·58 ± ·035	.. + ·56 ± ·037
Cortex thickness, 2 feet, 1923	+ ·42 ± ·044	.. + ·36 ± ·047
Number of latex vessel rows, 2 feet, 1923 ..	+ ·46 ± ·042	.. + ·38 ± ·046
Number of latex vessel rows, renewing cortex ..	—	.. + ·36 ± ·047
Thickness, renewing cortex ..	—	.. + ·34 ± ·048

The relationships between the characters in the foregoing table have, as will be seen, remained practically constant for the two years. It should be noted that the coefficient of correlation with girth is higher, and remains more nearly constant than do the coefficients for cortex thickness and number of latex vessel rows. Accordingly, as an indirect measure of yield, girth is a more accurate and reliable character than are cortex thickness and number of latex vessel rows. The differences between the coefficients for 1921–22 and 1922–23 are: girth ·02 ± ·051, cortex thickness ·06 ± ·064, latex vessel rows ·08 ± ·057; none of which is significant.

Table 31.

Correlation between Yield, 1922–23, and Renewing Cortex Thickness, 1923.

Yields, 1922–23. Grammes.		Renewing Cortex Thickness in Millimeters. 3·2	3·5	3·8	4·1	4·4	4·7	5·0	5·3	5·6	5·9	6·2		Total.
1,250	..	.	.	.	.	.	.	2	.	.	.	.	..	2
1,500	..	.	1	1	3	.	.	.	.	.	.	.	..	5
1,750	..	1	2	3	1	2	5	.	.	.	2	1	..	17
2,000	..	1		2	.	1	2	5	2	1	.	.	..	14
2,250	..	.	.	1	3	4	2	5	2	.	.	.	..	17
2,500	..	1	2	.	2	4	4	3	1	2	.	.	..	19
2,750	..	.	1	.	.	2	5	1	2	1	1	1	..	14
3,000	..	.	1	2	1	4	5	4	2	1	1	.	..	21
3,250	..	.	.	.	1	1	4	3	1	.	.	1	..	11
3,500	..	.	.	.	1	2	3	2	2	.	.	1	..	11
3,750	..	.	1	.	.	2	3	2	1	2	1	1	..	13
4,000	..	.	.	.	1	.	.	.	.	.	.	.	..	1
4,250	..	.	.	.	.	.	.	1	1	.	2	.	..	4
4,500	..	.	.	.	.	.	1	.	.	1	.	.	..	2
4,750	..	.	.	.	.	.	1	.	.	.	.	.	..	1
5,000	..	.	.	.	.	.	.	.	.	1	1	1	..	3
Total	..	3	8	9	13	22	35	28	14	9	8	6		155

Yield, 1922–23.		Renewing Cortex Thickness, 1923.	
Mean.	Standard Deviation.	Mean.	Standard Deviation.
2,773 gm.	810·1 gm.	4·74 mm.	·681 mm.

Coefficient of correlation + ·34 ± ·048.

Table 32.

Correlation between Yield, 1922–23, and Number of Latex Vessel Rows in Renewing Cortex, 1923.

Yield. Grammes.	9–10	11–12	13–14	15–16	17–18	19–20	21–22	23–24	25–26	27–28	29–30	31–32	33–34	35–36	37–38	39–40	41–42	Total.
1,250	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2
1,500	1	1	.	1	.	.	2	.	.	.	.	.	.	.	.	.	.	5
1,750	1	2	3	5	3	2	.	1	.	.	.	.	.	.	.	.	.	17
2,000	.	.	2	1	3	4	3	.	.	1	.	.	.	.	.	.	.	14
2,250	.	1	2	5	2	3	2	.	2	.	.	.	.	.	.	.	.	17
2,500	1	3	3	1	3	5	1	1	.	1	.	.	.	.	.	.	.	19
2,750	.	1	1	4	1	2	2	3	.	.	.	.	.	.	.	.	.	14
3,000	.	.	2	4	4	5	3	1	1	1	.	.	.	.	.	.	.	21
3,250	.	.	.	.	4	3	3	1	.	.	.	.	.	.	.	.	.	11
3,500	.	.	1	.	1	3	1	3	.	1	.	1	.	.	.	.	.	11
3,750	.	1	.	1	3	1	3	2	.	1	.	.	.	.	.	.	1	13
4,000	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	1
4,250	.	.	.	1	.	1	2	.	.	.	.	.	.	.	.	.	.	4
4,500	.	.	.	.	1	.	1	.	.	.	.	.	.	.	.	.	.	2
4,750	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	1
5,000	.	.	.	.	.	.	1	1	.	.	1	.	.	.	.	.	.	3
Total ..	3	9	16	24	26	29	24	13	3	5	1	1	0	0	0	0	1	155

Yield, 1922–23.		Number of Latex Vessel Rows in Renowing Cortex.	
Mean.	Standard Deviation.	Mean.	Standard Deviation.
2,773 gm.	810·1 gm.	18·6 rows	4·59 rows

Coefficient of correlation + ·365 ± ·047.

The coefficients of correlation between yield and the new characters—thickness and number of latex vessel rows of renewing cortex—have been calculated (Tables 31 and 32 respectively), and are given in Table 30. It is noteworthy that the relationship between yield and number of latex vessel rows in the renewing cortex is as close as that existing between yield and number of latex vessel rows in untapped cortex. A similar relationship exists between yield and thickness of untapped cortex and yield and thickness of renewing cortex. The relationships, therefore, between yield and characters of untapped cortex are not altered in degree in the succeeding renewing cortex.

Girth.

It was shown in a former Bulletin[4] that the character girth was interrelated, not only with yield, but also with the characters, cortex thickness and number of latex vessel rows. The coefficients of correlation for these characters, obtained from measurements made in 1921, are repeated in Table 33 to facilitate comparison with the coefficients obtained from the 1923 measurements.

Table 33.

Coefficients of Correlation between Girth, 1923, and Other Characters.

Other Characters.	Coefficients. 1921–22.	1922–23.
Girth, 1921 ..	— ..	+ ·95 ± ·006
Yield, 1922–23 ..	+ ·58 ± ·035 ..	+ ·56 ± ·037
Cortex thickness, 2 feet, 1923	+ ·63 ± ·032 ..	+ ·56 ± ·037
Number of latex vessel rows, 2 feet, 1923 ..	+ ·40 ± ·046 ..	+ ·11 ± ·054

From the above table it will be seen that, though in 1921 there was a decided relationship between girth and number of latex vessel rows, the same relationship is not shown by the 1923 measurements. The relationship between girth and cortex thickness has, however, remained constant.

Latex Vessel Rows.

The correlation table for number of latex vessel rows at 2 feet in 1921 and in 1923 gives a coefficient of + ·53 ± ·039, and this indicates that those trees which had most latex vessel rows in the first year still have most in the second year. The mean number of rows per tree at 2 feet from the ground rose from 11·3 rows to 19·7 rows in the period under review. How then have these various increases in the individual trees of the plot affected the degree of relationship of this character with

other characters as compared with the previous year? For ready comparison the coefficients of correlation between number of latex vessel rows and other characters for the years 1921 and 1923 are set down side by side in the following table :—

Table 34,

Coefficients of Correlation between Number of Latex Vessel Rows, 1923, and Other Characters.

Other Characters.	Coefficients.	
	1921–22.	1922–23.
Number of latex vessel rows, 2 feet, 1921 ..	—	.. + ·54 ± ·039
Yield, 1922–23 ..	+ ·46 ± ·042	.. + ·38 ± ·046
Girth, 1923 ..	+ ·40 ± ·046	.. + ·11 ± ·054
Cortex thickness, 2 feet, 1923	+ ·34 ± ·047	.. + ·14 ± ·053

The coefficient of correlation between number of latex vessel rows and yield has dropped slightly in 1923, but remains of the same order of magnitude as in 1921, and the relationship of these two characters is, therefore, unchanged.

In the cases, however, of girth and cortex thickness, there is a decided drop in 1923 in each coefficient. While in 1921 these coefficients indicated a small but definite correlation between these characters and the number of latex vessel rows, in 1923 these coefficients do not indicate any decided relationship.

Cortex Thickness.

The relationships of cortex thickness with other characters have been discussed in the preceding paragraphs under the characters concerned. The following table brings together the various coefficients of correlation to facilitate comparison :—

Table 35.

Coefficients of Correlation between Cortex Thickness, 1923, and Other Characters.

Other Characters.	Coefficients.	
	1921–22.	1922–23.
Cortex thickness, 1921 ..	—	.. + ·86 ± ·014
Yield, 1922–23 ..	+ ·46 ± ·044	.. + ·36 ± ·047
Girth, 1923 ..	+ ·63 ± ·032	.. + ·56 ± ·037
Number of latex vessel rows, 2 feet, 1923 ..	+ ·34 ± ·047	.. + ·14 ± ·053

Renewing Cortex.

It has already been shown that those trees, which had the thickest untapped cortex, have on the average produced the thickest renewing cortex. Also those trees which had the largest number of latex vessel rows in the untapped cortex have on the average the largest number in the renewing cortex. The coefficients of correlation for these characters are for convenience given in the following table, together with the coefficients for other relationships of the characters of the renewing cortex :—

Table 36.

Coefficients of Correlation between Characters of Renewing Cortex and Other Characters.

Other Characters.	Renewing Cortex.	Coefficients.
Yield, 1922–23 ..	Thickness ..	$+ \cdot 34 \pm \cdot 048$
Do. ..	Number of latex vessel rows ..	$+ \cdot 36 \pm \cdot 049$
Cortex thickness, 2 feet, 1923 ..	Thickness ..	$+ \cdot 42 \pm \cdot 045$
Number of latex vessel rows, 2 feet, 1923 ..	Number of latex vessel rows ..	$+ \cdot 69 \pm \cdot 028$
Renewing cortex thickness ..	do. ..	$+ \cdot 41 \pm \cdot 045$

From the foregoing table it will be seen that the relationship between the thickness of the renewing cortex and yield is the same as that between thickness of untapped cortex and yield ($+ \cdot 36 \pm \cdot 047$). The relationship between the number of rows of latex vessels in renewing cortex and yield also is similar to that between number of latex vessel rows in untapped cortex and yield ($+ \cdot 38 \pm \cdot 047$). These facts are additional proof of the statement already recorded, that the renewing cortex does not differ in character from the untapped cortex which preceded it. The coefficient of correlation between number of latex vessel rows in renewing cortex and in untapped cortex is considerably higher than that between thickness of renewing and untapped cortex, and indicates a correspondingly closer resemblance. Cortex thickness measurements would be affected by the rate of exfoliation of dead bark scales, a factor which would not affect a count of latex vessel rows to the same extent. At the same time it would appear not unlikely that latex vessel rows are laid down at fairly definite intervals, the total number present in the cortex being dependent on the character of the cortex concerned. In other words the number of latex vessel rows in the cortex is an inherent character exhibited by both renewing and untapped cortex.

Table 37.

Correlation between Thickness and Number of Latex Vessel Rows in Renewing Cortex, 1923.

Thickness. mm.		Number of Latex Vessel Rows. 9–10	11–12	13–14	15–16	17–18	19–20	21–22	23–24	25–26	27–28	29–30	31–32	33–34	35–36	37–38	39–40	41–42		Total.
3·2	..	.	1	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	..	3
3·5	..	1	2	1	.	.	2	2	.	.	.	.	.	.	.	.	.	.	..	8
3·8	..	.	1	1	3	3	.	1	.	.	.	.	.	.	.	.	.	.	..	9
4·1	..	1	.	3	6	1	.	2	.	.	.	.	.	.	.	.	.	.	..	13
4·4	..	1	.	.	3	9	6	.	2	.	1	.	.	.	.	.	.	.	..	22
4·7	..	.	3	5	4	6	6	4	4	2	1	.	.	.	.	.	.	.	..	35
5·0	..	.	.	4	2	3	11	4	2	1	1	.	.	.	.	.	.	.	..	28
5·3	..	.	.	1	3	2	2	3	3	.	.	.	.	.	.	.	.	.	..	14
5·6	..	.	1	.	.	1	1	3	1	.	2	.	.	.	.	.	.	.	..	9
5·9	..	.	1	.	2	.	1	3	.	.	.	1	.	.	.	.	.	.	..	8
6·2	..	.	.	.	.	1	.	2	1	.	.	.	1	.	.	.	.	1	..	6
Total	..	3	9	16	24	26	29	24	13	3	5	1	1	0	0	0	0	1		155

Thickness in Renewing Cortex. Mean.	Standard Deviation.	Number of Latex Vessel Rows in Renewing Cortex. Mean.	Standard Deviation.
4·74 mm.	·681 mm.	18·6 rows	4·59 rows

Coefficient of correlation $+ \cdot 41 \pm .045$.

The relationship between the thickness of the renewing cortex and the number of latex vessel rows which it contains (Table 37) corresponds to that determined for these characters in untapped cortex in 1921 (+ ·34 ± ·047). It differs, however, considerably from the relationship in untapped cortex in 1923. It should be noted here that the latex vessel rows in the renewing cortex are much more distinct than in untapped cortex, and a count is, therefore, not liable to such a great personal error.

Relationship between the Proportional Increases in Yield and in Other Characters.

It has already been shown that high yield is interrelated with big girth, numerous latex vessel rows, and thick cortex. It has also been indicated that there is considerable variation, not only in the actual quantities by which the yield of individual trees have increased during the second year of tapping, but also in the proportion that quantity bears to the first year's yield. In the second year the yield of some trees increased by more than 50 per cent. of their first year's yield, others have shown decreases, and some have remained constant. Variations have also occurred in the proportional increases in girth, number of latex vessel rows, and cortex thickness.

It would appear to be of some importance, therefore, to determine whether a change in yield has been accompanied by a corresponding change in girth, number of latex vessel rows, or cortex thickness. If a change in one character results in a corresponding change in another, it indicates that these characters are closely interlinked, and that any factor affecting one character will affect the others by a corresponding amount owing to the interlinking.

The true value of a change in a character is best measured by representing the increase or decrease as a percentage of the initial measurement. It is possible, therefore, by correlating percentage increase in yield with percentage increases in other characters, to determine whether yield is interlinked—and the extent of the interlinking—with these characters, and whether any relationship found between yield and other characters may be due to conditions other than the close interlinking of the characters.

In Table 38 the proportional increase in yield is correlated with the proportional increase in girth, and a coefficient of correlation of + ·03 ± ·054 has been obtained. This indicates that a change in yield, on the average, is *not* accompanied by a corresponding change in girth.

Table 38.

Correlation between Percentage Increase in Yield and Percentage Increase in Girth.

Percentage Increase in Girth.	Percentage Increase in Yield. —30	—20	—10	0	10	20	30	40	50	60	70	Total.
4 ..	.	.	.	.	.	1	.	.	.	.	.	1
7 ..	.	.	1	2	1	.	1	.	.	.	.	5
10 ..	.	.	2	3	3	5	3	.	.	.	1	17
13 ..	.	1	.	2	5	5	4	5	3	1	.	26
16 ..	1	2	.	1	8	9	11	6	4	.	.	42
19 ..	1	3	1	3	1	4	4	3	1	1	1	23
22 ..	1	.	.	1	2	2	2	1	.	1	.	10
25 ..	.	.	.	1	2	2	2	1	2	.	.	10
28 ..	.	.	.	.	.	1	1	2	3	.	.	7
31 ..	.	.	1	1	.	1	2	2	.	.	.	7
34 ..	.	.	.	1	.	.	.	.	.	.	.	1
37 ..	.	.	1	.	.	.	.	1	.	.	.	2
40 ..	.	.	1	.	1	.	1	.	.	.	.	3
43 ..	.	.	.	.	1	.	.	.	.	.	.	1
Total ..	3	6	7	15	24	30	31	21	13	3	2	155

Percentage Increase in Girth. Mean.	Standard Deviation.	Percentage Increase in Yield. Mean.	Standard Deviation.
18·13 per cent.	7·32 per cent.	21·3 per cent.	20·4 per cent.

Coefficient of correlation $+ \cdot 03 \pm \cdot 054$.

Table 39.

Correlation between Percentage Increase in Yield and Percentage Increase in Number of Latex Vessel Rows at 2 Feet, 1921–23.

Percentage Increase in Yield.		Percentage Increase in Number of Latex Vessel Rows.																Total
		10	30	50	70	90	110	130	150	170	190	210	230	250	270	290		
— 30	..	.	1	.	1	1	.	.	.	.	.	.	.	.	.	.	..	3
— 20	..	.	1	2	1	1	.	.	.	.	.	.	.	.	.	.	..	5
— 10	..	1	.	1	1	1	1	.	.	.	2	.	.	.	.	.	..	7
0	..	.	2	6	2	2	1	.	1	.	1	.	.	.	.	.	..	15
+ 10	..	1	4	10	4	1	2	.	.	.	.	1	1	.	.	.	..	24
20	..	2	2	7	9	1	3	4	2	.	.	.	1	.	.	.	..	31
30	..	2	3	8	6	4	3	2	2	.	.	.	.	1	.	.	..	31
40	..	2	1	4	2	3	4	1	2	.	.	1	.	.	.	1	..	21
50	..	.	1	1	2	5	1	.	1	1	.	.	.	1	.	.	..	13
60	..	.	.	.	1	2	.	.	.	.	.	.	.	.	.	.	..	3
70	..	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	..	2
Total	..	8	15	39	29	21	17	7	8	1	3	2	2	2	0	1		155

Percentage Increase in Yield.		Percentage Increase in Number of Latex Vessel Rows.	
Mean.	Standard Deviation.	Mean.	Standard Deviation.
21·3 per cent.	20·4 per cent.	82·5 per cent.	51·6 per cent.

Coefficient of correlation $+ \cdot 15 \pm \cdot 053$.

Similarly the percentage increase in yield has been correlated with the percentage increase in the number of latex vessel rows at 2 feet (Table 39) and with the proportional increase in latex vessel rows on descending the tree from 2 feet to 8 inches (Table 40). The coefficients of correlation for these characters were found to be + ·15 ± ·052 and + ·14 ± ·053, respectively. The interlinking of yield with number of latex vessel rows, as indicated by these coefficients, is neglible, the change in number of latex vessel rows, whether measured at 2 feet or by descending the tree to 8 inches, being unaccompanied by any decided change in yield.

Since a proportional increase in the number of latex vessel rows does not result in a corresponding proportional increase in yield, it is unlikely that this relationship exists between percentage increase in yield and percentage increase in number of latex vessel rows in renewing cortex, and that this is the case is shown by the coefficient of correlation between these characters + ·024 ± ·054.

The coefficient of correlation between percentage increase in yield and percentage increase in cortex thickness (Table 41) is + ·16 ± ·053, while for percentage thickness of renewing cortex it is + ·11 ± ·054. As the first coefficient indicates no relationship, it would be expected that no relationship would be indicated by the second coefficient, and this is the case.

The coefficient of correlation between percentage increase in yield and that of other characters are brought together in Table 42 to facilitate comparison.

Table 42.

Coefficients of Correlation between the Percentage Increase in Yield and the Percentage Increase in Other Characters.

Other Characters.	Coefficients.
Girth	+ ·03 ± ·054
Number of latex vessel rows, 2 feet ..	+ ·15 ± ·052
Number of latex vessel rows descending from 2 feet to 8 inches	+ ·14 ± ·053
Number of latex vessel rows, renewing cortex ..	+ ·02 ± ·054
Cortex thickness, 2 feet	+ ·16 ± ·053
Renewing cortex thickness	+ ·11 ± ·054

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Table 40.

Correlation between Percentage Increase in Yield and Percentage Increase in Number of Latex Vessel Rows descending from 2 Feet to 8 Inches.

Percentage Increase in Yield.	Percentage Increase in Number of Latex Vessel Rows. —20	—15	—10	—5	0	5	10	15	20	25	30	35	40, &c.	80	Total.
— 30 ..	.	.	.	.	2	1	.	.	.	.	.	.	.	.	3
— 20 ..	.	.	.	1	2	2	.	.	.	1	.	.	.	.	6
— 10 ..	.	.	1	.	4	.	.	1	1	.	.	.	.	.	7
0 ..	.	.	1	1	3	4	1	3	1	.	.	1	.	.	15
+ 10 ..	.	1	1	1	4	1	4	6	4	.	.	.	1	1	24
20 ..	1	.	3	4	7	4	7	1	.	1	1	1	.	.	30
30 ..	.	2	3	4	8	5	7	1	1	.	.	.	.	.	31
40 ..	1	2	1	2	5	4	3	1	.	1	1	.	.	.	21
50 ..	.	1	1	3	2	3	1	2	.	.	.	.	.	.	13
60 ..	.	.	.	1	.	1	.	1	.	.	.	.	.	.	3
70 ..	.	.	.	.	1	.	1	.	.	.	.	.	.	.	2
Total ..	2	6	11	17	38	25	24	16	7	3	2	2	1	1	155

Percentage Increase in Yield.

Mean.	Standard Deviation.
21·3 per cent.	20·4 per cent.

Percentage Increase in Number of Latex Vessel Rows descending from 2 Feet to 8 Inches.

Mean.	Standard Deviation.
4·80 per cent.	12·35 per cent.

Coefficient of correlation = — ·14 ± ·053.

Table 41.

Correlation between Percentage Increase in Yield and Percentage Increase in Cortex Thickness at 2 Feet.

Percentage Increase in Yield.	Percentage Increase in Cortex Thickness. 10	15	20	25	30	35	40	45	50	55	60	Total.
— 30 ..	.	.	.	1	2	.	.	.	.	.	.	3
— 20 ..	.	2	1	1	2	.	.	.	.	.	.	6
— 10 ..	1	1	1	1	1	.	1	.	1	.	.	7
0 ..	1	3	2	1	2	3	1	2	.	.	.	15
+ 10 ..	1	7	4	7	3	2	.	.	.	.	.	24
20 ..	1	4	5	4	3	7	4	.	2	.	.	30
30 ..	2	2	7	4	9	3	3	.	.	.	1	31
40 ..	.	2	2	7	2	1	4	2	1	.	.	21
50 ..	.	.	1	6	.	.	2	2	.	2	.	13
60 ..	2	.	.	.	.	.	1	.	.	.	.	3
—	.	.	1	.	1	.	.	.	.	.	.	2
Total ..	8	21	24	32	25	16	16	6	4	2	1	155

Percentage Increase in Yield.		Percentage Increase in Cortex Thickness at 2 Feet.	
Mean.	Standard Deviation.	Mean.	Standard Deviation.
21·3 per cent.	20·4 per cent.	27·5 per cent.	10·55 per cent.

Coefficient of correlation + ·16 ± ·053.

Relationship between the Proportional Increases in Girth and in Other Characters.

Since a change in yield is not accompanied by equivalent changes in other characters, it is important to determine whether these other characters are interlinked to any extent amongst themselves.

The relationship between percentage increase in girth and percentage increase in number of latex vessel rows is shown in Table 43. The coefficient of correlation between these characters is $+ \cdot 55 \pm \cdot 038$, and this indicates a close relationship. Accordingly, a proportional increase in girth is accompanied by a proportional increase in number of latex vessel rows. Any factor, therefore, affecting the one character on the average affects the other to an equivalent degree and in the same direction.

The relationship between percentage increase in girth and percentage increase in cortex thickness is shown in Table 44. Here again the coefficient of correlation $+ \cdot 40 \pm \cdot 045$ indicates a close relationship between these characters. An increase in girth, therefore, is accompanied by not only a proportional increase in number of latex vessel rows, but also by a proportional increase in cortex thickness.

The coefficients of correlation between percentage increases in girth and other characters are given below in Table 45 :—

Table 45.

Coefficients of Correlation between Percentage Increase in Girth and Percentage Increase in Other Characters.

Other Characters.	Coefficients.
Number of latex vessel rows, 2 feet ..	$+ \cdot 55 \pm \cdot 038$
Cortex thickness, 2 feet ..	$+ \cdot 40 \pm \cdot 045$
Yield	$+ \cdot 03 \pm \cdot 054$

Relationship between the Proportional Increases in Number of Latex Vessel Rows and Other Characters.

The remaining relationship to be investigated between the percentage increases of characters is that between the percentage increases in cortex thickness and in number of latex vessel rows. The relationship between these characters is shown in Table 46. The coefficient of correlation is $+ \cdot 30 \pm \cdot 049$, indicating a relationship, though not a very decided one, between these characters.

Table 43.
Correlation between Percentage Increase in Girth and Percentage Increase in Number of Latex Vessel Rows at 2 Feet, 1921–23.

Percentage Increase in Girth.		Percentage Increase in Number of Latex Vessel Rows. 10	30	50	70	90	110	130	150	170	190	210	230	250	270	290		Total.
4	..	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	..	1
7	..	.	1	3	.	1	.	.	.	.	.	.	.	.	.	.	..	5
10	..	1	2	7	5	1	1	.	.	.	.	.	.	.	.	.	..	17
13	..	1	4	9	4	4	2	1	1	.	.	.	.	.	.	.	..	26
16	..	3	1	11	10	5	7	3	1	1	.	.	.	.	.	.	..	42
19	..	1	5	4	5	4	3	1	.	.	.	.	.	.	.	.	..	23
22	..	1	1	1	1	2	2	1	1	.	.	.	.	.	.	.	..	10
25	..	.	1	1	1	2	.	1	1	.	.	.	1	1	.	1	..	10
28	..	.	.	1	2	1	.	.	3	.	.	.	.	.	.	.	..	7
31	..	.	.	2	1	.	2	.	1	.	.	1	.	.	.	.	..	7
34	..	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	..	1
37	..	.	.	.	.	1	.	.	.	.	1	.	.	.	.	.	..	2
40	..	.	.	.	.	.	.	.	.	.	1	1	.	1	.	.	..	3
43	..	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	..	1
Total	..	8	15	39	29	21	17	7	8	1	3	2	2	2	0	1		155

Percentage Increase in Girth.		Percentage Increase in Number of Latex Vessel Rows, 2 Feet, 1921–23.	
Mean.	Standard Deviation.	Mean.	Standard Deviation.
18·13 per cent.	7·32 per cent.	82·5 per cent.	51·6 per cent.

Coefficient of correlation = + ·55 ± ·038.

Table 44.

Correlation between Percentage Increase in Girth and Percentage Increase in Cortex Thickness, 1921–23.

Percentage Increase in Cortex Thickness.		Percentage Increase in Girth. 4	7	10	13	16	19	22	25	28	31	34	37	40	43		Total.
10	..	.	.	2	1	3	2	.	.	.	.	.	.	.	.	..	8
15	..	.	2	5	4	7	2	.	.	.	.	.	1	.	.	..	21
20	..	.	.	5	1	9	7	1	.	.	.	.	.	1	.	..	24
25	..	.	2	2	8	9	4	1	3	1	1	.	.	.	1	..	32
30	..	.	.	2	5	6	7	1	2	.	2	.	.	.	.	..	25
35	..	1	1	1	4	3	.	2	2	2	.	.	.	.	.	..	16
40	..	.	.	.	3	3	.	4	1	1	2	.	1	1	.	..	16
45	..	.	.	.	.	1	.	.	1	2	1	1	.	.	.	..	6
50	..	.	.	.	.	1	1	.	.	.	1	.	.	1	.	..	4
55	..	.	.	.	.	.	.	.	1	1	.	.	.	.	.	..	2
60	..	.	.	.	.	.	.	1	.	.	.	.	.	.	.	..	1
Total	...	1	5	17	26	42	23	10	10	7	7	1	2	3	1		155

Percentage Increase in Cortex Thickness.		Percentage Increase in Girth.	
Mean.	Standard Deviation.	Mean.	Standard Deviation.
27·5 per cent.	10·55 per cent.	18·13 per cent.	7·32 per cent.

Coefficient of correlation = + ·40 ± ·045.

Table 46.

Correlation between Percentage Increase in Number of Latex Vessel Rows and Percentage Increase in Cortex Thickness at 2 Feet.

Percentage Increase in Cortex Thickness.		Percentage Increase in Number of Latex Vessel Rows.																Total.
		10	30	50	70	90	110	130	150	170	190	210	230	250	270	290		
10	..	1	1	3	2	1	.	.	.	.	.	.	.	.	.	.	..	8
15	..	1	4	4	6	2	1	1	1	.	1	.	.	.	.	.	..	21
20	..	2	1	5	8	3	4	.	.	.	.	1	.	.	.	.	..	24
25	..	.	2	12	5	4	3	2	1	.	.	1	2	.	.	.	..	32
30	..	1	5	6	3	5	3	1	1	.	.	.	.	.	.	.	..	25
35	..	1	2	5	.	1	3	2	2	.	.	.	.	.	.	.	..	16
40	..	2	.	3	2	4	2	.	2	.	.	.	.	1	.	.	..	16
45	..	.	.	.	2	1	.	.	.	1	1	.	.	.	.	1	..	6
50	..	.	.	1	1	.	1	.	.	.	1	.	.	.	.	.	..	4
55	..	.	.	.	.	.	.	.	1	.	.	.	.	1	.	.	..	2
60	..	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	..	1
Total	..	8	15	39	29	21	17	7	8	1	3	2	2	2	0	1		155

Percentage Increase in Cortex Thickness.		Percentage Increase in Number of Latex Vessel Rows, 2 Feet, 1921–23.	
Mean.	Standard Deviation.	Mean.	Standard Deviation.
27·5 per cent.	10·55 per cent.	82·5 per cent.	51·6 per cent.

Coefficient of correlation = + ·30 ± ·049.

The coefficients for the various relationships between percentage increase in number of latex vessel rows and percentage increase in other characters are collected in Table 47 below :—

Table 47.

Coefficients of Correlation between Percentage Increase in Number of Latex Vessel Rows and Percentage Increase in Other Characters.

Other Characters.	Coefficients.
Girth	+ ·55 ± ·038
Cortex thickness 2 feet ..	+ ·30 ± ·049
Yield	+ ·15 ± ·052

RELATIONSHIP BETWEEN THE PROPORTIONAL INCREASES IN CORTEX THICKNESS AND OTHER CHARACTERS.

The relationships between percentage increase of cortex thickness and other characters have already been discussed in the preceding sections, but for convenience of reference and comparison the various coefficients are collected in Table 48.

Table 48.

Coefficients of Correlation between Percentage Increase in Cortex Thickness at 2 Feet from Ground Level and Percentage Increase in Other Characters.

Other Characters.	Coefficients.
Girth	+ ·40 ± ·045
Number of latex vessel rows, 2 feet ..	+ ·30 ± ·049
Yield	+ ·16 ± ·053

From the foregoing table it will be seen that a closer relationship exists between percentage increases in cortex thickness and girth than in the case of the other characters mentioned in the table.

INTERLINKING OF CHARACTERS.

A study of the foregoing paragraphs on relationships discloses the remarkable fact that though actual yield is related to actual girth, number of latex vessel rows, and cortex thickness, changes in yield are not accompanied by corresponding changes in those characters. On the other hand, not only is there a close relationship between these characters (excluding yield), but also changes in one are accompanied by corresponding changes in the others. This indicates that girth, number of latex vessel rows, and cortex thickness are closely interlinked; any factor affecting one results in a corresponding

the percentage increases in yield and girth is too small to denote any real correlation between these characters. It is evident, therefore, that the age factor resulting in an increase in the length of the tapping cut and in the number of rows of latex vessels cannot be the main cause determining increase in yield.

This conclusion is supported by general observations on estates to the effect that a reduction in yield occurs when the tapping cut is changed over from the base to the opposite side at a higher level. Such a change over results in a slight decrease in the length of the cut, but not in a decided decrease in the number of latex vessel rows tapped.

The change over of the tapping cut from the base to a higher level on the other side of stem is made in one step. The short interval of time occupied by the change over may be considered as instantaneous with regard to any effect of the age factor on yield. The age factor, therefore, does not enter into any comparison of the yields obtained before and after the change over. It has already been shown, however, that a decrease in the length of the tapping cut is not accompanied by a corresponding diminution in the yield. The decrease in yield on changing over cannot be due to age, to shorter tapping cuts, nor to the tapping of a diminished number of latex vessel rows.

It has not been possible to determine any relationship between the increase in yield obtained as the tapping cut descends the tree and increases in measurements of other characters investigated.

The explanation of the increase in yield as the tapping cut descends the tree and of decrease in yield on changing over from the base to a higher level must be sought in other directions. It may be suggested that other factors may have some influence on this phenomenon, such as greater pressure within the latex vessels at lower levels, differences in viscosity of the latex and diameter of the latex vessels, or other anatomical or physiological characters.

It would, therefore, appear that the lower portion of the stem is inherently higher yielding, and that there is a steady falling off in yield capacity as the height from ground level increases. Experience gained in estate practice has resulted in the restriction of the tapping cut to the lowest possible portion of the stem compatible with the system of tapping adopted. The scientific evidence so far collected is in agreement with estate experience on this point.

Growth.

The natural growth of a tree results in an increase in height, in girth, in extent of branching, and generally in increase in

size. . Of these, girth is the most easily measured character, and in trees growth is usually measured by the girth. A rapid increase in girth denotes rapid growth. The annual increase in girth is a measure of the annual growth, and if this is expressed as a percentage or proportion of the initial measurement, a measure of rate of growth is obtained. A small tree, for example, of which the girth increases by 2 inches in one year, is growing proportionately more rapidly than a larger tree with the same increase, and therefore shows a higher growth rate.

It has been shown in Table 11 that the nett increase in girth of the smallest trees is on the average equal to that of the biggest trees, but that in proportion to their initial size the smallest trees have made the greatest growth.

The relationship between initial girth and percentage increase is represented by the coefficient of correlation $-\cdot 40 \pm \cdot 046$ (Table 10), which indicates that the trees which had the smallest girth in April, 1921, have made the greatest proportional increase in girth. The smallest trees are, therefore, growing most rapidly.

The coefficients of correlation between the percentage increases in girth and the percentage increases in other characters (Table 45) indicate that the trees which have made the greatest increases in girth have also made the greatest increases in cortex thickness and in number of latex vessel rows in the cortex. The coefficient for the percentage increases in girth and in yield is, however, too small to denote any decided relationship between these characters. Changes in girth, therefore, have generally been accompanied by corresponding changes in cortex thickness and in number of latex vessel rows, but *not by changes in yield.*

In the cases of cortex thickness and number of latex vessel rows the relationship between initial measurement and the percentage increase is of the same nature as that already found for girth (Tables 23 and 15). Girth, then, cortex thickness, and number of latex vessel rows all exhibit the same relationship with their percentage increases. On the other hand, the relationship between initial yield and percentage increase in yield is of an *opposite* nature to that found between each of the three foregoing characters and their percentage increases. Trees with the *highest* initial yield show also the *highest* percentage increase in yield (Table 5), whereas trees with the *lowest* initial measurements of girth, cortex thickness, and number of latex vessel rows show the *highest* percentage increases in these characters.

The three characters—girth, cortex thickness, and number of latex vessel rows—are so interlinked that a change in one is

accompanied by a corresponding change in the others. Any increase in the rate of growth results in an increase in cortex thickness, number of latex vessel rows, as well as in girth. Increase in the rate of growth does *not*, however, result in increase in yield. Increase in yield must, therefore, be considered to be independent of the growth rate.

Growth and Yield.

It is not generally recognized that increase in yield is independent of increased growth and conversely that increased growth is not necessarily accompanied by increased yield. These facts are important in their bearing on estate practice in that methods of cultivation directed toward encouraging increase in growth do not necessarily result in increase in yield. Where increase in yield has occurred following such methods of cultivation, it must be considered as a direct effect of such treatment on yield, rather than an indirect effect through any increased growth that may be induced.

Estate cultivation consists principally of working the soil and manuring, and the direct result of this treatment is increased growth. With regard to other crops, such as tea, coconuts, and cacao, increased growth thus induced results in bigger crops, but the nature of the crop is in these cases vastly different to the crop in the case of rubber. In the case of tea the crop is the leaf, and the more vigorous the growth the more abundantly leaf is produced. In coconuts and cacao the crop is the fruit which consists mainly of food materials manufactured by the leaves. The rubber crop, however, is derived from the latex, and though the function of the latex is still unknown, its value to the tree appears to be small, as the loss occasioned by tapping does not greatly diminish growth. There is then no apparent connection between latex production and growth. The following table illustrates the point here discussed :—

Table 50.

Comparison between Increase in Girth of High- and Low-yielding Groups.

	No. of Trees.	Mean Yield.	Mean Girth Increase.
High Group ..	37 ..	3,875 gm. ..	8·0 cm.
Low Group ..	45 ..	1,873 gm. ..	7·5 cm.

The High Group consists of 37 trees, which in 1922–23 gave more than 3,319 grammes each. The Low Group consists of 45 trees with yields of less than 2,227 grammes, *i.e.*, the worst yielders of the plot. It will be seen that each tree in the High Group has on the average yielded 2,002 grammes of rubber

more than the average of the Low Group, and this difference is slightly more than 110 per cent. of the mean of the Low Group. The mean increase in girth of the High Group from January, 1922, to April, 1923, is, however, only 0·5 cm., or 6·7 per cent. above that of the Low Group.

It has been shown in Table 38 that those trees which during the course of these investigations have made the greatest percentage increases in girth are not in general the trees which have given the greatest percentage increases in yield, the coefficient of correlation for these characters being $+ \cdot 03 \pm \cdot 054$. If increase in girth is regarded as a measure of growth activity, then increase in yield cannot be ascribed to the same cause.

Of the many manurial experiments carried out on rubber no one experiment, to the knowledge of the writers, has indubitably proved that the application of manures has increased the yield of rubber. That applications of manure increase the growth and general vigour of the trees is undoubted, as it is possible to distinguish manured from unmanured fields at a distance by their general appearance. Manuring probably promotes also a more rapid regeneration of the renewing cortex, increase in cortex thickness being interlinked with increase in girth. Manuring therefore maintains the general vigour of the trees, but there is no evidence that it increases the yield.

These observations lead to the conclusion that yield is independent of vegetative vigour. Yield is an inherent character; a tree is, in general, born a good yielder or a bad yielder, and no special cultivation or treatment will convert a poor yielder into a good yielder. It is possible, however, owing to disease or to unfavourable conditions that high yielders may become mediocre or even poor. Cultivation in estate practice should, therefore, be directed toward the maintenance of the trees in normal conditions of health and growth, to enable them to give the greatest yields that their inherent character renders possible.

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July, 1923.

Bibliography.

[1] Ashplant, H. Which estate in South India has the highest-yielding rubber tree? The Planters' Chronicle, XVII., p. 664 (December, 1922).

[2] Bobilioff, W. Over de Correlatie tusschen de Productie en het Aantal Rijen der melksapvaten in den Bast van Hevea brasiliensis. Archief v. d. Rubbercultuur, IV., p. 383 (October, 1920).

[3] Bryce, G., and Campbell, L. E. On the Mode of Occurrence of Latex Vessels in Hevea brasiliensis. Dept. of Agric., Ceylon, Bull. 30 (January, 1917).

[4] Bryce, G., and Gadd, C. H. Improvement of Yield in Hevea by the Selection of Seed Bearers. Dept. of Agric., Ceylon, Bull. 55 (November, 1922).

[5] Bryce, G., and Gadd, C. H. Hevea Selection. Year Book of the Dept. of Agric., Ceylon, 1923, p. 28.

[6] Gehlsen, C. A. De Waarde van het Bastonderzoek voor de Plantsoensveredeling. Archief v. d. Rubbercultuur, V., p. 453 (September, 1921).

[7] Petch, T. The Girth Increment of Hevea brasiliensis. Annals, R. B. G., Peradeniya, VI., p. 77 (November, 1916).

[8] la Rue, C. D. Structure and Yield in Hevea brasiliensis. Archief v. d. Rubbercultuur, V., p. 574 (December, 1921).

[9] Vischer, W. De Anatomische Bouw van het Latexvatenstelsel bij Hevea in verband met de Latex-productie. Archief v. d. Rubbercultuur, IV., p. 473 (October, 1920).

[10] Whitby, S. Variation in Hevea brasiliensis. Annals of Botany, XXXIII., p. 313 (1919).

Table 1.—Measurement Records.

Tree No.	Yield. 1921–22. gm.	Yield. 1922–23. gm.	Untapped Cortex Number of Latex Vessel Rows. At 2 ft.	Untapped Cortex Number of Latex Vessel Rows. At 8 in.	Untapped Cortex Thickness. At 2 ft. mm.	Untapped Cortex Thickness. At 8 in. mm.	Girth. c.m.	Renewing Cortex No. of L. V. R.	Renewing Cortex Thickness. mm.
1..	2,663..	3,007..	21..	19..	7·1..	8·2..	108·0..	16..	4·7
2..	1,756..	1,532..	12..	12..	6·9..	6·9..	75·3..	12..	3·9
3..	1,842..	1,794..	15..	18..	7·8..	6·8..	96·9..	20..	4·4
4..	1,971..	2,682..	17..	18..	8·3..	7·9..	110·7..	22..	5·7
5..	3,277..	5,088..	25..	21..	7·8..	7·1..	127·5..	29..	6·0
6..	2,235..	2,840..	24..	25..	6·8..	5·8..	89·6..	23..	6·1
7..	2,632..	3,686..	22..	18..	7·3..	6·7..	113·6..	12..	5·7
8..	1,537..	1,694..	15..	18..	5·4..	5·3..	75·6..	15..	4·0
9..	1,586..	1,580..	20..	20..	5·4..	5·6..	57·2..	21..	4·2
10..	1,824..	1,690..	14..	14..	5·7..	6·1..	90·8..	17..	4·3
*11..	1,716..	1,167..	20..	20..	5·6..	5·5..	85·1..	21..	4·2
12..	2,994..	3,867..	27..	32..	7·6..	7·2..	95·0..	28..	5·6
13..	1,846..	2,489..	25..	28..	7·4..	6·8..	80·7..	23..	5·2

* Went dry October, 1922.

Tree No.	Yield. 1921-22.	Yield. 1922-23.	Untapped Cortex. Number of Latex Vessel Rows. At 2 ft.	Untapped Cortex. Number of Latex Vessel Rows. At 8 in.	Untapped Cortex. Thickness. At 2 ft.	Untapped Cortex. Thickness. At 8 in.	Girth.	Renewing Cortex. No. of L. V. R.	Renewing Cortex. Thickness.
	gm.	gm.			mm.	mm.	cm.		mm.
14	1,911	2,147	23	27	6·8	6·4	86·1	25	4·7
15	1,572	1,963	24	24	5·0	5·0	87·4	21	3·8
16	1,595	1,741	15	14	7·3	7·5	82·3	13	4·7
17	2,194	2,277	20	23	6·8	6·6	84·2	20	4·5
18	2,715	3,687	29	32	6·9	6·4	82·6	20	3·5
19	2,069	2,477	30	27	7·8	6·9	85·8	20	4·5
20	2,012	2,827	22	21	5·5	5·3	75·3	19	4·6
21	2,139	3,097	24	22	6·4	6·6	83·6	20	5·0
*22	2,373	1,913	21	20	7·0	6·0	95·3	21	4·7
23	2,380	2,329	19	19	9·4	8·6	106·9	20	5·0
24	1,694	2,049	16	18	7·5	6·4	71·8	19	4·9
25	2,071	3,066	19	18	6·1	5·9	100·9	19	5·1
26	1,905	2,153	23	28	8·1	6·7	89·6	22	4·1
27	2,405	2,994	17	19	7·9	8·0	106·3	20	5·4
28	1,633	1,956	20	22	5·8	4·9	73·0	28	4·3
29	1,824	1,950	17	19	6·9	5·9	92·7	19	5·0
30	2,054	2,556	16	15	6·3	6·4	74·9	13	4·7
31	1,951	1,809	20	20	6·1	5·5	68·9	14	3·6
32	2,762	4,418	21	20	7·9	6·3	126·9	21	5·5
33	2,159	2,549	22	21	5·7	5·7	77·5	20	3·5
34	1,639	2,457	20	21	5·7	4·7	95·4	11	4·6
35	1,732	1,409	18	18	4·1	3·8	49·9	21	3·6
36	2,656	3,556	18	18	7·6	7·2	98·9	14	4·1
37	2,267	3,214	21	20	6·2	5·8	95·0	22	5·2
38	2,875	4,495	20	23	7·2	6·5	101·2	18	4·8
39	2,062	2,319	24	24	8·3	7·3	94·6	22	5·4
40	1,990	2,788	20	20	6·5	4·6	77·5	23	5·2
41	2,581	3,836	38	36	6·5	5·9	75·0	41	6·2
42	2,870	3,629	20	22	9·1	7·8	97·8	18	4·8
43	2,026	2,469	22	27	7·1	6·4	96·5	17	4·3
44	1,828	2,081	20	22	6·5	6·8	97·2	22	4·7
45	2,556	3,634	22	22	7·3	6·8	103·1	23	4·8
46	1,721	1,677	14	15	7·5	7·3	100·6	15	3·8
47	2,615	3,512	26	28	7·8	7·6	105·4	27	4·6
48	2,710	2,115	21	20	7·3	6·5	92·4	18	5·2
49	2,219	2,961	18	18	8·0	7·5	121·2	18	5·2
50	1,740	1,783	15	17	5·4	4·1	63·5	15	3·7
51	2,927	4,306	23	27	6·9	6·0	97·8	20	5·0
52	2,397	3,015	19	21	7·3	6·5	89·9	18	4·4
53	2,069	2,918	19	16	6·3	5·3	82·3	15	4·7
54	2,758	4.330	19	20	8·1	8·8	120·9	16	5·2
55	1,977	2,459	11	11	5·4	5·8	85·1	11	3·2
56	1,886	2,129	10	18	8·4	8·4	104·4	13	5·2
57	2,775	3,938	19	19	5·9	4·8	103·4	15	4·0
58	1,946	2,563	26	27	6·3	6·1	95·9	28	5·5
59	1,966	2,106	18	20	6·8	6·1	91·2	18	5·1
60	2,174	2,712	17	18	6·8	6·1	104·4	16	5·9
61	1,900	2,651	19	19	6·9	6·3	78·1	15	4·3
62	2,398	2,601	13	18	7·5	8·1	90·8	14	4·2
63	2,387	3,188	27	28	7·6	6·9	93·4	23	4·9

* Went dry September, 1922.

Tree No.	Yield. 1921–22. gm.	1922–23. gm.	Untapped Cortex Number of Latex Vessel Rows. At 2 ft.	At 8 in.	Thickness. At 2 ft. mm.	At 8 in. mm.	Girth. cm.	Renewing Cortex. No. of L. V. R.	Thickness. mm.
64	2,380	3,472	31	29	7·4	6·3	107·6	24	5·0
65	2,459	3,641	22	25	7·5	5·5	92·1	23	4·8
66	2,209	3,142	17	22	6·7	6·6	86·4	20	4·4
67	3,693	4,944	27	30	8·7	7·5	110·4	23	5·6
68	2,401	2,923	18	23	7·8	6·5	92·1	17	4·5
69	2,411	3,139	17	18	7·2	6·8	101·9	17	5·0
70	2,633	3,096	21	21	8·1	7·7	101·6	17	3·9
71	2,988	3,529	23	22	8·3	6·5	125·0	17	4·7
72	2,435	3,302	19	21	6·5	5·7	98·4	17	4·0
73	2,647	3,526	25	23	8·7	7·1	104·4	24	4·5
74	2,478	3,206	22	21	6·4	5·9	83·8	20	4·9
75	2,220	2,927	17	17	6·7	7·0	110·4	13	4·2
*76	1,704	131	17	17	6·6	6·5	89·6	10	3·8
77	2,220	2,620	25	22	8·5	7·4	89·6	17	5·5
78	2,602	2,883	19	22	7·3	7·0	78·7	19	4·4
79	2,505	3,105	26	29	7·7	7·8	118·0	27	4·9
80	1,746	2,214	14	12	6·4	6·1	93·0	15	4·3
81	2,671	3,224	23	25	7·5	7·5	100·6	17	4·7
82	3,260	4,296	25	24	8·5	8·0	101·6	21	5·9
83	3,045	3,865	16	14	7·1	7·0	94·6	22	5·8
84	2,092	2,277	16	18	7·5	5·2	91·2	15	4·3
†85	1,952	1,216	12	14	6·4	5·8	91·4	13	4·2
86	2,231	2,855	17	16	7·9	6·7	107·5	14	5·0
87	1,726	1,825	19	19	6·7	6·6	65·1	18	3·8
‡88	1,649	1,514	23	23	7·2	6·4	98·4	16	4·0
89	2,016	2,026	23	21	7·6	6·6	81·6	22	5·1
90	1,798	1,848	16	17	6·4	6·4	80·3	15	5·8
91	1,919	1,678	23	23	6·2	6·2	77·8	24	4·7
92	2,327	2,055	22	20	7·5	6·9	102·8	20	5·7
93	2,776	3,470	26	28	7·4	6·4	124·1	24	5·2
94	2,169	2,487	19	21	6·6	6·2	96·5	20	4·6
95	1,949	2,149	18	19	6·9	6·2	97·5	13	4·9
96	2,264	1,721	22	23	8·6	8·0	120·9	18	6·3
97	2,306	2,276	24	23	6·4	6·4	96·2	18	4·3
98	2,214	2,416	18	21	7·3	7·2	95·3	14	4·8
99	2,268	2,618	21	22	6·5	6·5	94·3	11	3·5
100	2,590	1,719	26	26	6·7	6·6	101·6	20	4·6
101	2,132	2,680	19	17	8·9	6·3	95·0	15	5·2
102	2,585	3,647	20	20	9·4	7·4	108·5	22	5·1
103	1,725	2,344	14	15	6·1	4·8	98·1	15	4·1
104	1,696	1,785	11	13	6·2	5·2	87·6	13	4·6
105	2,463	3,572	36	39	7·7	7·3	107·6	31	6·3
106	1,606	2,071	15	16	6·7	6·5	98·1	16	5·2
107	1,714	1,426	15	19	7·9	6·8	86·7	9	4·2
108	2,069	2,581	20	20	8·0	7·5	88·6	16	4·2
109	2,756	4,704	20	20	8·7	8·7	112·9	17	4·8
110	1,759	1,819	13	14	8·7	8·0	91·8	12	5·8
§111	1,668	1,306	25	22	7·0	4·5	87·4	21	4·9

* Went dry January, 1922.
† Went dry September, 1922.
‡ Dry from January, 1922, till June, 1922.
§ Went dry November, 1922.

Tree No.	Yield. 1921-22. gm.	Yield. 1922-23. gm.	Untapped Cortex. Number of Latex Vessel Rows. At 2 ft.	Untapped Cortex. Number of Latex Vessel Rows. At 8 in.	Untapped Cortex. Thickness. At 2 ft. mm.	Untapped Cortex. Thickness. At 8 in. mm.	Girth. cm.	Renewing Cortex. No. of L. V. R.	Renewing Cortex. Thickness. mm.
112	2,040	2,832	24	27	6·7	5·9	97·2	24	4·8
113	2,223	3,265	25	25	6·9	6·1	97·5	18	4·6
114	2,454	2,937	25	25	6·8	7·2	75·3	25	4·8
115	2,544	3,832	23	25	8·8	7·0	96·5	21	5·2
116	1,901	2,261	22	22	7·5	6·9	82·3	16	4·2
117	1,844	1,361	18	18	5·5	6·4	54·6	13	4·9
118	1,392	1,330	15	17	5·8	6·8	62·2	13	4·9
119	2,001	2,902	16	16	7·4	7·5	97·2	13	3·9
120	1,580	1,397	14	17	6·4	5·6	81·3	15	4·0
121	2,134	2,580	20	19	7·2	8·1	84·8	21	5·0
122	1,728	1,690	16	17	5·4	5·1	98·2	16	3·2
123	2,114	2,401	16	19	7·2	4·9	94·1	17	4·4
124	2,495	1,961	26	27	8·1	7·1	101·2	19	4·9
125	1,988	2,436	14	15	7·6	7·0	105·3	10	4·5
126	2,162	2,965	12	15	7·0	7·2	106·6	16	5·0
127	1,943	2,293	20	16	7·6	6·3	83·6	15	3·9
128	2,195	2,320	22	19	6·4	6·1	74·9	20	5·1
129	1,888	1,869	15	16	7·4	6·3	68·9	11	4·8
130	2,382	3,499	19	20	6·5	5·9	95·3	20	4·4
131	2,450	3,422	25	21	7·4	7·0	110·7	21	5·0
132	2,302	3,357	21	19	7·0	6·9	90·5	22	6·3
133	2,784	3,674	21	21	7·2	7·6	101·9	18	4·4
134	1,942	2,319	20	22	7·6	6·7	88·3	18	4·9
135	2,356	3,592	19	20	6·9	6·0	116·1	19	5·3
136	2,299	2,700	11	12	5·7	5·9	67·6	12	3·4
137	2,504	3,148	27	27	10·1	6·9	96·5	20	4·8
138	3,019	4,981	24	26	7·4	6·3	110·4	22	6·1
139	2,417	2,549	16	16	7·4	6·7	95·4	19	5·0
140	1,820	1,885	15	20	6·5	6·5	78·1	17	3·8
141	2,533	2,984	18	19	7·3	6·5	98·1	23	4·3
142	2,015	2,142	10	10	7·6	8·0	98·1	12	4·7
143	2,250	2,080	23	27	6·1	6·3	91·2	14	3·2
144	2,108	2,208	17	17	5·8	5·3	90·8	25	4·9
145	2,535	2,724	13	15	8·6	7·8	108·2	17	4·5
146	2,290	2,669	14	19	6·5	7·0	99·7	15	4·6
147	2,055	2,582	14	13	7·1	6·4	110·4	20	5·1
148	2,500	2,915	19	19	10·4	10·1	112·9	20	6·0
149	2,456	2,881	12	13	8·1	8·0	119·9	15	4·6
150	2,035	2,690	15	17	7·6	8·2	90·5	19	4·7
151	2,494	3,331	20	20	7·5	7·0	92·1	22	4·8
152	2,332	2,635	16	18	7·5	6·6	102·8	21	4·8
153	2,080	1,755	12	12	6·0	5·5	84·8	9	3·4
154	2,823	3,741	18	18	7·8	7·6	116·1	16	4·9
155	2,528	2,999	19	17	6·9	6·3	93·4	21	4·6
156	2,355	3,047	23	23	6·2	5·6	90·2	22	3·5
157	2,359	3,048	21	23	7·6	8·5	116·8	22	5·5
158	2,659	3,514	23	20	7·0	7·5	90·8	19	4·6
159	2,572	3,653	14	15	7·4	6·3	100·6	18	4·5
160	2,965	4,132	20	21	7·8	6·8	103·1	21	6·0
161	2,795	2,006	16	17	8·7	8·7	116·4	13	4·7

at the base and at ground level. In the other type the number of latex vessels rapidly decreases from the base upwards. This latter type is of less value in practice."

It has been shown that in the present plot the mean number of rows at 2 feet in 1923 was $19 \cdot 7 \pm \cdot 257$, and at 8 inches was $20 \cdot 4 \pm \cdot 258$. The difference ($\cdot 7$ rows) is small in comparison with its probable error, and is consequently insignificant. Expressed in practical terms this statistical result means that a tapping cut at 8 inches does not, on the average, open more latex vessel rows than a tapping cut at 2 feet. The increased 1922–23 yields are, therefore, not to be attributed to any increase in the number of rows of latex vessels as the tapping cut moves down the stem. The same conclusion is reached by consideration of Table 40, which shows the relationship between the percentage increase in yield and the percentage increase in the number of latex vessel rows on descending the tree from 2 feet to 8 inches; from this the coefficient of correlation has been calculated to be $- \cdot 14 \pm \cdot 053$. This coefficient indicates no decided relationship between these two percentage increases within the limits of these experiments. The change in yield of individual trees is accordingly not associated with a corresponding change in the number of latex vessel rows as the cut reaches lower levels on the stem. The explanation of the increase in yield which corresponds with the descent of the tapping cut must, therefore, be sought in other directions.

Before proceeding to an examination of other factors, it would appear advisable to test Vischer's conclusions that there are two types of Hevea distinguishable by the variation in the number of rows at various heights, and that the type which has a much larger number of latex vessel rows at ground level than at a considerable distance above ground level, is of less value from the point of view of yield. In practice tapping is restricted to the basal 2 or 3 feet of the tree, and, consequently, the type of lesser value must show within these limits a decreasing number of vessels from the ground upwards.

Vischer's conclusions were based on the examination of five trees only. By the application of his method of classification of types of Hevea to Table 1, it may be ascertained by comparing the number of latex vessel rows of each tree at 2 feet with the number at 8 inches, that in the present plot there are three types of Hevea trees :—

(1) With a *greater* number of rows at 8 inches than at 2 feet.
(2) With the *same* number of rows at 8 inches as at 2 feet.
(3) With a *smaller* number of rows at 8 inches than at 2 feet.

Types (1) and (2) agree with Vischer's types, the first being that which he considers inferior in practice.

An examination of Fig. 8, which represents graphically the frequency distribution (given in Table 18) of the number of latex vessel rows at 8 inches expressed as a percentage of the number of rows at 2 feet, shows that there is no evidence to justify the division of the trees of the plot into three or even into two types. The curve in Fig. 8 is approximately normal, indicating that the population, from which the measurements were made, is truly homogeneous, and consequently of one type only. It will be seen from that figure that there are more trees in the class which has approximately the same number of rows at 8 inches and 2 feet (100 per cent.) than in any other class, and that the numbers fall away symmetrically on each side as the divergence from the mode (fashion) increases. If there were three types of tree in the plot, there would be three modes, and the curve would be heaped up in three places, each one indicating a type. The presence of Vischer's inferior type in the plot would, therefore, be indicated by an additional mode at some point above 100 per cent. Fig. 8 indicates that there is only one type, viz., that having approximately the same number of rows at 2 feet and at 8 inches, and that this type varies in both directions. Accordingly, trees may be found with either a greater or smaller number of rows at 2 feet than at 8 inches, but those trees must be considered rather as variations of the one type than as distinct types.

Since Vischer's conclusions are based on examination of five trees only, without further evidence there is considerable doubt as to the validity of Vischer's types.

There is then but one type of tree in the plot, and that type has approximately the same number of rows of latex vessels at 2 feet and at 8 inches. It has also been demonstrated that the increase in yield as the tapping cut descends the tree is not due solely to the tapping of an increasing number of latex vessel rows. The factors to which increase in yield may be attributed must, therefore, be sought in other directions.

In the first place, the tree is becoming older as the tapping cut descends. Is therefore the increased yield due mainly to increasing age ?

During the two years 1921 to 1923 there has been an increase in the number of latex vessel rows at 2 feet. Similarly, the girth has increased during the same time, and consequently the tapping cut has become longer. It has already been pointed out, however, that the relationship existing between percentage increase in yield and percentage increase in the number of latex vessel rows at 2 feet in the two years is very small, the coefficient of correlation being $+ \cdot 15 \pm \cdot 053$. Similarly, the coefficient of correlation ($+ \cdot 03 \pm \cdot 054$) between

the percentage increases in yield and girth is too small to denote any real correlation between these characters. It is evident, therefore, that the age factor resulting in an increase in the length of the tapping cut and in the number of rows of latex vessels cannot be the main cause determining increase in yield.

This conclusion is supported by general observations on estates to the effect that a reduction in yield occurs when the tapping cut is changed over from the base to the opposite side at a higher level. Such a change over results in a slight decrease in the length of the cut, but not in a decided decrease in the number of latex vessel rows tapped.

The change over of the tapping cut from the base to a higher level on the other side of stem is made in one step. The short interval of time occupied by the change over may be considered as instantaneous with regard to any effect of the age factor on yield. The age factor, therefore, does not enter into any comparison of the yields obtained before and after the change over. It has already been shown, however, that a decrease in the length of the tapping cut is not accompanied by a corresponding diminution in the yield. The decrease in yield on changing over cannot be due to age, to shorter tapping cuts, nor to the tapping of a diminished number of latex vessel rows.

It has not been possible to determine any relationship between the increase in yield obtained as the tapping cut descends the tree and increases in measurements of other characters investigated.

The explanation of the increase in yield as the tapping cut descends the tree and of decrease in yield on changing over from the base to a higher level must be sought in other directions. It may be suggested that other factors may have some influence on this phenomenon, such as greater pressure within the latex vessels at lower levels, differences in viscosity of the latex and diameter of the latex vessels, or other anatomical or physiological characters.

It would, therefore, appear that the lower portion of the stem is inherently higher yielding, and that there is a steady falling off in yield capacity as the height from ground level increases. Experience gained in estate practice has resulted in the restriction of the tapping cut to the lowest possible portion of the stem compatible with the system of tapping adopted. The scientific evidence so far collected is in agreement with estate experience on this point.

Growth.

The natural growth of a tree results in an increase in height, in girth, in extent of branching, and generally in increase in

size. Of these, girth is the most easily measured character, and in trees growth is usually measured by the girth. A rapid increase in girth denotes rapid growth. The annual increase in girth is a measure of the annual growth, and if this is expressed as a percentage or proportion of the initial measurement, a measure of rate of growth is obtained. A small tree, for example, of which the girth increases by 2 inches in one year, is growing proportionately more rapidly than a larger tree with the same increase, and therefore shows a higher growth rate.

It has been shown in Table 11 that the nett increase in girth of the smallest trees is on the average equal to that of the biggest trees, but that in proportion to their initial size the smallest trees have made the greatest growth.

The relationship between initial girth and percentage increase is represented by the coefficient of correlation $- \cdot 40 \pm \cdot 046$ (Table 10), which indicates that the trees which had the smallest girth in April, 1921, have made the greatest proportional increase in girth. The smallest trees are, therefore, growing most rapidly.

The coefficients of correlation between the percentage increases in girth and the percentage increases in other characters (Table 45) indicate that the trees which have made the greatest increases in girth have also made the greatest increases in cortex thickness and in number of latex vessel rows in the cortex. The coefficient for the percentage increases in girth and in yield is, however, too small to denote any decided relationship between these characters. Changes in girth, therefore, have generally been accompanied by corresponding changes in cortex thickness and in number of latex vessel rows, but *not by changes in yield*.

In the cases of cortex thickness and number of latex vessel rows the relationship between initial measurement and the percentage increase is of the same nature as that already found for girth (Tables 23 and 15). Girth, then, cortex thickness, and number of latex vessel rows all exhibit the same relationship with their percentage increases. On the other hand, the relationship between initial yield and percentage increase in yield is of an *opposite* nature to that found between each of the three foregoing characters and their percentage increases. Trees with the *highest* initial yield show also the *highest* percentage increase in yield (Table 5), whereas trees with the *lowest* initial measurements of girth, cortex thickness, and number of latex vessel rows show the *highest* percentage increases in these characters.

The three characters—girth, cortex thickness, and number of latex vessel rows—are so interlinked that a change in one is

accompanied by a corresponding change in the others. Any increase in the rate of growth results in an increase in cortex thickness, number of latex vessel rows, as well as in girth. Increase in the rate of growth does *not*, however, result in increase in yield. Increase in yield must, therefore, be considered to be independent of the growth rate.

Growth and Yield.

It is not generally recognized that increase in yield is independent of increased growth and conversely that increased growth is not necessarily accompanied by increased yield. These facts are important in their bearing on estate practice in that methods of cultivation directed toward encouraging increase in growth do not necessarily result in increase in yield. Where increase in yield has occurred following such methods of cultivation, it must be considered as a direct effect of such treatment on yield, rather than an indirect effect through any increased growth that may be induced.

Estate cultivation consists principally of working the soil and manuring, and the direct result of this treatment is increased growth. With regard to other crops, such as tea, coconuts, and cacao, increased growth thus induced results in bigger crops, but the nature of the crop is in these cases vastly different to the crop in the case of rubber. In the case of tea the crop is the leaf, and the more vigorous the growth the more abundantly leaf is produced. In coconuts and cacao the crop is the fruit which consists mainly of food materials manufactured by the leaves. The rubber crop, however, is derived from the latex, and though the function of the latex is still unknown, its value to the tree appears to be small, as the loss occasioned by tapping does not greatly diminish growth. There is then no apparent connection between latex production and growth. The following table illustrates the point here discussed :—

Table 50.

Comparison between Increase in Girth of High- and Low-yielding Groups.

	No. of Trees.	Mean Yield.	Mean Girth Increase.
High Group ..	37 ..	3,875 gm. ..	8·0 cm.
Low Group ..	45 ..	1,873 gm. ..	7·5 cm.

The High Group consists of 37 trees, which in 1922–23 gave more than 3,319 grammes each. The Low Group consists of 45 trees with yields of less than 2,227 grammes, *i.e.*, the worst yielders of the plot. It will be seen that each tree in the High Group has on the average yielded 2,002 grammes of rubber

more than the average of the Low Group, and this difference is slightly more than 110 per cent. of the mean of the Low Group. The mean increase in girth of the High Group from January, 1922, to April, 1923, is, however, only 0·5 cm., or 6·7 per cent. above that of the Low Group.

It has been shown in Table 38 that those trees which during the course of these investigations have made the greatest percentage increases in girth are not in general the trees which have given the greatest percentage increases in yield, the coefficient of correlation for these characters being $+ \cdot 03 \pm \cdot 054$. If increase in girth is regarded as a measure of growth activity, then increase in yield cannot be ascribed to the same cause.

Of the many manurial experiments carried out on rubber no one experiment, to the knowledge of the writers, has indubitably proved that the application of manures has increased the yield of rubber. That applications of manure increase the growth and general vigour of the trees is undoubted, as it is possible to distinguish manured from unmanured fields at a distance by their general appearance. Manuring probably promotes also a more rapid regeneration of the renewing cortex, increase in cortex thickness being interlinked with increase in girth. Manuring therefore maintains the general vigour of the trees, but there is no evidence that it increases the yield.

These observations lead to the conclusion that yield is independent of vegetative vigour. Yield is an inherent character ; a tree is, in general, born a good yielder or a bad yielder, and no special cultivation or treatment will convert a poor yielder into a good yielder. It is possible, however, owing to disease or to unfavourable conditions that high yielders may become mediocre or even poor. Cultivation in estate practice should, therefore, be directed toward the maintenance of the trees in normal conditions of health and growth, to enable them to give the greatest yields that their inherent character renders possible.

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July, 1923.

Bibliography.

[1] Ashplant, H. Which estate in South India has the highest-yielding rubber tree ? The Planters' Chronicle, XVII., p. 664 (December, 1922).

[2] Bobilioff, W. Over de Correlatie tusschen de Productie en het Aantal Rijen der melksapvaten in den Bast van Hevea brasiliensis. Archief v. d. Rubbercultuur, IV., p. 383 (October, 1920).

[3] Bryce, G., and Campbell, L. E. On the Mode of Occurrence of Latex Vessels in Hevea brasiliensis. Dept. of Agric., Ceylon, Bull. 30 (January, 1917).

[4] Bryce, G., and Gadd, C. H. Improvement of Yield in Hevea by the Selection of Seed Bearers. Dept. of Agric., Ceylon, Bull. 55 (November, 1922).

[5] Bryce, G., and Gadd, C. H. Hevea Selection. Year Book of the Dept. of Agric., Ceylon, 1923, p. 28.

[6] Gehlsen, C. A. De Waarde van het Bastonderzoek voor de Plantsoensveredeling. Archief v. d. Rubbercultuur, V., p. 453 (September, 1921).

[7] Petch, T. The Girth Increment of Hevea brasiliensis. Annals, R. B. G., Peradeniya, VI., p. 77 (November, 1916).

[8] la Rue, C. D. Structure and Yield in Hevea brasiliensis. Archief v. d. Rubbercultuur, V., p. 574 (December, 1921).

[9] Vischer, W. De Anatomische Bouw van het Latexvatenstelsel bij Hevea in verband met de Latex-productie. Archief v. d. Rubbercultuur, IV., p. 473 (October, 1920).

[10] Whitby, S. Variation in Hevea brasiliensis. Annals of Botany, XXXIII., p. 313 (1919).

Table 1.—Measurement Records.

Tree No.	Yield. 1921–22. gm.	Yield. 1922–23. gm.	Untapped Cortex Number of Latex Vessel Rows. At 2 ft.	Untapped Cortex Number of Latex Vessel Rows. At 8 in.	Untapped Cortex Thickness. At 2 ft. mm.	Untapped Cortex Thickness. At 8 in. mm.	Girth. c.m.	Renewing Cortex No. of L. V. R.	Renewing Cortex Thickness. mm.
1	2,663	3,007	21	19	7·1	8·2	108·0	16	4·7
2	1,755	1,532	12	12	6·9	6·9	75·3	12	3·9
3	1,842	1,794	15	18	7·8	6·8	96·9	20	4·4
4	1,971	2,682	17	18	8·3	7·9	110·7	22	5·7
5	3,277	5,088	25	21	7·8	7·1	127·5	29	6·0
6	2,235	2,840	24	25	6·8	5·8	89·6	23	6·1
7	2,632	3,686	22	18	7·3	6·7	113·6	12	5·7
8	1,537	1,694	15	18	5·4	5·3	75·6	15	4·0
9	1,586	1,580	20	20	5·4	5·6	57·2	21	4·2
10	1,824	1,690	14	14	5·7	6·1	90·8	17	4·3
*11	1,716	1,167	20	20	5·6	5·5	85·1	21	4·2
12	2,994	3,867	27	32	7·6	7·2	95·0	28	5·6
13	1,846	2,489	25	28	7·4	6·8	80·7	23	5·2

* Went dry October, 1922.

Tree No.	Yield.		Untapped Cortex Number of Latex Vessel Rows.		Thickness.		Girth.	Renewing Cortex.	
	1921–22.	1922–23.	At 2 ft.	At 8 in.	At 2 ft.	At 8 in.		No. of L. V. R.	Thickness.
	gm.	gm.			mm.	mm.	cm.		mm.
14	1,911	2,147	23	27	6·8	6·4	86·1	25	4·7
15	1,572	1,963	24	24	5·0	5·0	87·4	21	3·8
16	1,595	1,741	15	14	7·3	7·5	82·3	13	4·7
17	2,194	2,277	20	23	6·8	6·6	84·2	20	4·5
18	2,715	3,687	29	32	6·9	6·4	82·6	20	3·5
19	2,069	2,477	30	27	7·8	6·9	85·8	20	4·5
20	2,012	2,827	22	21	5·5	5·3	75·3	19	4·6
21	2,139	3,097	24	22	6·4	6·6	83·6	20	5·0
*22	2,373	1,913	21	20	7·0	6·0	95·3	21	4·7
23	2,380	2,329	19	19	9·4	8·6	106·9	20	5·0
24	1,694	2,049	16	18	7·5	6·4	71·8	19	4·9
25	2,071	3,066	19	18	6·1	5·9	100·9	19	5·1
26	1,905	2,153	23	28	8·1	6·7	89·6	22	4·1
27	2,405	2,994	17	19	7·9	8·0	106·3	20	5·4
28	1,633	1,956	20	22	5·8	4·9	73·0	28	4·3
29	1,824	1,950	17	19	6·9	5·9	92·7	19	5·0
30	2,054	2,556	16	15	6·3	6·4	74·9	13	4·7
31	1,951	1,809	20	20	6·1	5·5	68·9	14	3·6
32	2,762	4,418	21	20	7·9	6·3	126·9	21	5·5
33	2,159	2,549	22	21	5·7	5·7	77·5	20	3·5
34	1,639	2,457	20	21	5·7	4·7	95·4	11	4·6
35	1,732	1,409	18	18	4·1	3·8	49·9	21	3·6
36	2,656	3,556	18	18	7·6	7·2	98·9	14	4·1
37	2,267	3,214	21	20	6·2	5·8	95·0	22	5·2
38	2,875	4,495	20	23	7·2	6·5	101·2	18	4·8
39	2,062	2,319	24	24	8·3	7·3	94·6	22	5·4
40	1,990	2,788	20	20	6·5	4·6	77·5	23	5·2
41	2,581	3,836	38	36	6·5	5·9	75·0	41	6·2
42	2,870	3,629	20	22	9·1	7·8	97·8	18	4·8
43	2,026	2,469	22	27	7·1	6·4	96·5	17	4·3
44	1,828	2,081	20	22	6·5	6·8	97·2	22	4·7
45	2,556	3,634	22	22	7·3	6·8	103·1	23	4·8
46	1,721	1,677	14	15	7·5	7·3	100·6	15	3·8
47	2,615	3,512	26	28	7 8	7·6	105·4	27	4·6
48	2,710	2,115	21	20	7·3	6·5	92·4	18	5·2
49	2,219	2,961	18	18	8·0	7·5	121·2	18	5·2
50	1,740	1,783	15	17	5·4	4·1	63·5	15	3·7
51	2,927	4,306	23	27	6·9	6·0	97·8	20	5·0
52	2,397	3,015	19	21	7·3	6·5	89·9	18	4·4
53	2,069	2,918	19	16	6·3	5·3	82·3	15	4·7
54	2,758	4,330	19	20	8·1	8·8	120·9	16	5·2
55	1,977	2,459	11	11	5·4	5·8	85·1	11	3·2
56	1,886	2,129	10	18	8·4	8·4	104·4	13	5·2
57	2,775	3,938	19	19	5·9	4·8	103·4	15	4·0
58	1,946	2,563	26	27	6·3	6·1	95·9	28	5·5
59	1,966	2,106	18	20	6·8	6·1	91·2	18	5·1
60	2,174	2,712	17	18	6·8	6·1	104·4	16	5·9
61	1,900	2,651	19	19	6·9	6·3	78·1	15	4·3
62	2,398	2,601	13	18	7·5	8·1	90·8	14	4·2
63	2,387	3,188	27	28	7·6	6·9	93·4	23	4·9

* Went dry September, 1922.

Tree No.	Yield. 1921–22.	Yield. 1922–23.	Untapped Cortex Number of Latex Vessel Rows. At 2 ft.	Untapped Cortex Number of Latex Vessel Rows. At 8 in.	Untapped Cortex Thickness. At 2 ft.	Untapped Cortex Thickness. At 8 in.	Girth.	Renewing Cortex. No. of L. V. R.	Renewing Cortex. Thickness.
	gm.	gm.			mm.	mm.	cm.		mm.
64..	2,380..	3,472..	31..	29..	7·4..	6·3..	107·6..	24..	5·0
65..	2,459..	3,641..	22..	25..	7·5..	5·5..	92·1..	23..	4·8
66..	2,209..	3,142..	17..	22..	6·7..	6·6..	86·4..	20..	4·4
67..	3,693..	4,944..	27..	30..	8·7..	7·5..	110·4..	23..	5·6
68..	2,401..	2,923..	18..	23..	7·8..	6·5..	92·1..	17..	4·5
69..	2,411..	3,139..	17..	18..	7·2..	6·8..	101·9..	17..	5·0
70..	2,633..	3,096..	21..	21..	8·1..	7·7..	101·6..	17..	3·9
71..	2,988..	3,529..	23..	22..	8·3..	6·5..	125·0..	17..	4·7
72..	2,435..	3,302..	19..	21..	6·5..	5·7..	98·4..	17..	4·0
73..	2,647..	3,526..	25..	23..	8·7..	7·1..	104·4..	24..	4·5
74..	2,478..	3,206..	22..	21..	6·4..	5·9..	83·8..	20..	4·9
75..	2,220..	2,927..	17..	17..	6·7..	7·0..	110·4..	13..	4·2
*76..	1,704..	131..	17..	17..	6·6..	6·5..	89·6..	10..	3·8
77..	2,220..	2,620..	25..	22..	8·5..	7·4..	89·6..	17..	5·5
78..	2,602..	2,883..	19..	22..	7·3..	7·0..	78·7..	19..	4·4
79..	2,505..	3,105..	26..	29..	7·7..	7·8..	118·0..	27..	4·9
80..	1,746..	2,214..	14..	12..	6·4..	6·1..	93·0..	15..	4·3
81..	2,671..	3,224..	23..	25..	7·5..	7·5..	100·6..	17..	4·7
82..	3,260..	4,296..	25..	24..	8·5..	8·0..	101·6..	21..	5·9
83..	3,045..	3,865..	16..	14..	7·1..	7·0..	94·6..	22..	5·8
84..	2,092..	2,277..	16..	18..	7·5..	5·2..	91·2..	15..	4·3
†85..	1,952..	1,216..	12..	14..	6·4..	5·8..	91·4..	13..	4·2
86..	2,231..	2,855..	17..	16..	7·9..	6·7..	107·5..	14..	5·0
87..	1,726..	1,825..	19..	19..	6·7..	6·6..	65·1..	18..	3·8
‡88..	1,649..	1,514..	23..	23..	7·2..	6·4..	98·4..	16..	4·0
89..	2,016..	2,026..	23..	21..	7·6..	6·6..	81·6..	22..	5·1
90..	1,798..	1,848..	16..	17..	6·4..	6·4..	80·3..	15..	5·8
91..	1,919..	1,678..	23..	23..	6·2..	6·2..	77·8..	24..	4·7
92..	2,327..	2,055..	22..	20..	7·5..	6·9..	102·8..	20..	5·7
93..	2,776..	3,470..	26..	28..	7·4..	6·4..	124·1..	24..	5·2
94..	2,169..	2,487..	19..	21..	6·6..	6·2..	96·5..	20..	4·6
95..	1,949..	2,149..	18..	19..	6·9..	6·2..	97·5..	13..	4·9
96..	2,264..	1,721..	22..	23..	8·6..	8·0..	120·9..	18..	6·3
97..	2,306..	2,276..	24..	23..	6·4..	6·4..	96·2..	18..	4·3
98..	2,214..	2,416..	18..	21..	7·3..	7·2..	95·3..	14..	4·8
99..	2,268..	2,618..	21..	22..	6·5..	6·5..	94·3..	11..	3·5
100..	2,590..	1,719..	26..	26..	6·7..	6·6..	101·6..	20..	4·6
101..	2.132..	2,680..	19..	17..	8·9..	6·3..	95·0..	15..	5·2
102..	2,585..	3.647..	20..	20..	9·4..	7·4..	108·5..	22..	5·1
103..	1,725..	2.344..	14..	15..	6·1..	4·8..	98·1..	15..	4·1
104..	1,696..	1,785..	11..	13..	6·2..	5·2..	87·6..	13..	4·6
105..	2,468..	3,572..	36..	39..	7·7..	7·3..	107·6..	31..	6·3
106..	1,606..	2,071..	15..	16..	6·7..	6·5..	98·1..	16..	5·2
107..	1,714..	1,426..	15..	19..	7·9..	6·8..	86·7..	9..	4·2
108..	2,069..	2,581..	20..	20..	8·0..	7·5..	88·6..	16..	4·2
109..	2,756..	4,704..	20..	20..	8·7..	8·7..	112·9..	17..	4·8
110..	1,759..	1,319..	13..	14..	8·7..	8·0..	91·8..	12..	5·8
§111..	1,668..	1,306..	25..	22..	7·0..	4·5..	87·4..	21..	4·9

* Went dry January, 1922.
† Went dry September, 1922.
‡ Dry from January, 1922, till June, 1922.
§ Went dry November, 1922.

Tree No.	Yield.		Untapped Cortex. Number of Latex Vessel Rows.		Untapped Cortex. Thickness.		Girth.	Renewing Cortex.	
	1921-22.	1922-23.	At 2 ft.	At 8 in.	At 2 ft.	At 8 in.		No. of L. V. R.	Thickness.
	gm.	gm.			mm.	mm.	cm.		mm.
112..	2,040..	2,832..	24..	27..	6·7..	5·9..	97·2..	24..	4·8
113..	2,223..	3,265..	25..	25..	6·9..	6·1..	97·5..	18..	4·6
114..	2,454..	2,937..	25..	25..	6·8..	7·2..	75·3..	25..	4·8
115..	2,544..	3,832..	23..	25..	8·8..	7·0..	96·5..	21..	5·2
116..	1,901..	2,261..	22..	22..	7·5..	6·9..	82·3..	16..	4·2
117..	1,844..	1,361..	18..	18..	5·5..	6·4..	54·6..	13..	4·9
118..	1,392..	1,330..	15..	17..	5·8..	6·8..	62·2..	13..	4·9
119..	2,001..	2,902..	16..	16..	7·4..	7·5..	97·2..	13..	3·9
120..	1,580..	1,397..	14..	17..	6·4..	5·6..	81·3..	15..	4·0
121..	2,134..	2,580..	20..	19..	7·2..	8·1..	84·8..	21..	5·0
122..	1,728..	1,690..	16..	17..	5·4..	5·1..	98·2..	16..	3·2
123..	2,114..	2,401..	16..	19..	7·2..	4·9..	94·1..	17..	4·4
124..	2,495..	1,961..	26..	27..	8·1..	7·1..	101·2..	19..	4·9
125..	1,988..	2,436..	14..	15..	7·6..	7·0..	105·3..	10..	4·5
126..	2,162..	2,965..	12..	15..	7·0..	7·2..	106·6..	16..	5·0
127..	1,943..	2,293..	20..	16..	7·6..	6·3..	83·6..	15..	3·9
128..	2,195..	2,320..	22..	19..	6·4..	6·1..	74·9..	20..	5·1
129..	1,888..	1,869..	15..	16..	7·4..	6·3..	68·9..	11..	4·8
130..	2,382..	3,499..	19..	20..	6·5..	5·9..	95·3..	20..	4·4
131..	2,450..	3,422..	25..	21..	7·4..	7·0..	110·7..	21..	5·0
132..	2,302..	3,357..	21..	19..	7·0..	6·9..	90·5..	22..	6·3
133..	2,784..	3,674..	21..	21..	7·2..	7·6..	101·9..	18..	4·4
134..	1,942..	2,319..	20..	22..	7·6..	6·7..	88·3..	18..	4·9
135..	2,356..	3,592..	19..	20..	6·9..	6·0..	116·1..	19..	5·3
136..	2,299..	2,700..	11..	12..	5·7..	5·9..	67·6..	12..	3·4
137..	2,504..	3,148..	27..	27..	10·1..	6·9..	96·5..	20..	4·8
138..	3,019..	4,981..	24..	26..	7·4..	6·3..	110·4..	22..	6·1
139..	2,417..	2,549..	16..	16..	7·4..	6·7..	95·4..	19..	5·0
140..	1,820..	1,885..	15..	20..	6·5..	6·5..	78·1..	17..	3·8
141..	2,533..	2,984..	18..	19..	7·3..	6·5..	98·1..	23..	4·3
142..	2,015..	2,142..	10..	10..	7·6..	8·0..	98·1..	12..	4·7
143..	2,250..	2,080..	23..	27..	6·1..	6·3..	91·2..	14..	3·2
144..	2,108..	2,208..	17..	17..	5·8..	5·3..	90·8..	25..	4·9
145..	2,535..	2,724..	13..	15..	8·6..	7·8..	108·2..	17..	4·5
146..	2,290..	2,669..	14..	19..	6·5..	7·0..	99·7..	15..	4·6
147..	2,055..	2,582..	14..	13..	7·1..	6·4..	110·1..	20..	5·1
148..	2,500..	2,915..	19..	19..	10·4..	10·1..	112·9..	20..	6·0
149..	2,456..	2,881..	12..	13..	8·1..	8·0..	119·9..	15..	4·6
150..	2,035..	2,690..	15..	17..	7·6..	8·2..	90·5..	19..	4·7
151..	2,494..	3,331..	20..	20..	7·5..	7·0..	92·1..	22..	4·8
152..	2,332..	2,635..	16..	18..	7·5..	6·6..	102·8..	21..	4·8
153..	2,080..	1,755..	12..	12..	6·0..	5·5..	84·8..	9..	3·4
154..	2,823..	3,741..	18..	18..	7·8..	7·6..	116·1..	16..	4·9
155..	2,528..	2,999..	19..	17..	6·9..	6·3..	93·4..	21..	4·6
156..	2,355..	3,047..	23..	23..	6·2..	5·6..	90·2..	22..	3·5
157..	2,359..	3,048..	21..	23..	7·6..	8·5..	116·8..	22..	5·5
158..	2,659..	3,514..	23..	20..	7·0..	7·5..	90·8..	19..	4·6
159..	2,572..	3,653..	14..	15..	7·4..	6·3..	100·6..	18..	4·5
160..	2,965..	4,132..	20..	21..	7·8..	6·8..	103·1..	21..	6·0
161..	2,795..	2,006..	16..	17..	8·7..	8·7..	116·4..	13..	4·7